Narrative Review

Pathways of parental influence on adolescent diet and obesity: a psychological stress–focused perspective

Sarah M. Dimitratos, Johnna R. Swartz, and Kevin D. Laugero

Youth obesity has become increasingly prevalent, with 34.5% of US adolescents 12–19 years old estimated to have overweight or obesity. Disordered eating and weight concern peak in adolescence, and overeating to cope with negative emotions can affect long-term health and obesity risk. Parents significantly influence adolescent diet quality, and parental stress may influence parenting behaviors that increase the risk for stress-motivated eating and obesity in adolescents. Chronic or repeated exposure to parental stress may lead to stress-related neurophysiological changes that promote consumption of palatable foods and obesogenic eating habits in adolescents. Understanding how parental stress influences adolescents' eating behavior may reveal novel access points for reducing adolescent obesity. Here, we aim to provide a new stress-focused framework for developing intervention strategies targeted at obesity prevention in adolescents.

INTRODUCTION

An estimated 34.5% of adolescents 12–19 years old have overweight or obesity, according to data from the National Health and Nutrition Examination Survey on obesity prevalence in 2011–2012.[1] Alarmingly, these statistics are projected to increase. Given that adolescents gain substantial weight, skeletal mass, and height to reach adult size during this critical developmental period, suboptimal eating habits established during adolescence have important long-term behavioral and health consequences.[2] Many factors contribute to youth obesity, including, but not limited to, genetic background, socioeconomic disparities, limited or no access to grocery stores and safe play areas for adequate physical activity, media use, and low adherence to guidelines for weight-related behaviors.[3–6] Among the many potential risk factors, poor diet in excess of caloric needs is a key contributor to childhood obesity.[7] Adolescents in the United States fall short of dietary recommendations of fruits, vegetables, and whole grains, while consumption of added sugars and empty calories remains high.[8] Prior research has delineated a number of different processes that may lead to poor diet in children and adolescents, including food advertising, health literacy, access to sugar-sweetened beverages, influence of family and peers, low socioeconomic status, low availability of fresh fruits and vegetables and overabundance of nutrient-sparse food options. Furthermore, personal factors such as hunger, taste preferences, and lack of urgency about the health consequences of a poor diet also contribute.[9,10] Another important factor contributing to adolescents' eating habits and obesity is parenting behavior, especially parental

Affiliation: *S.M. Dimitratos* and *K.D. Laugero* are with the Obesity and Metabolism Research Unit, USDA/ARS/Western Human Nutrition Research Center; and Department of Nutrition, University of California, Davis, California, USA. *J.R. Swartz* is with the Department of Human Ecology, University of California, Davis, California, USA.

Correspondence: *K.D. Laugero*, Obesity and Metabolism Research Unit, USDA/ARS/Western Human Nutrition Research Center, 430 West Health Sciences Dr, Davis, CA 95616, USA. E-mail: kevin.laugero@ars.usda.gov.

Key words: adolescent health, diet quality, obesity, parenting, stress.

https://doi.org/10.1093/nutrit/nuac004

stress, which has received less attention in the literature than other contributing factors to poor diet and health status in adolescents.

Our goal for this narrative review is to summarize current knowledge regarding different pathways through which parenting may affect adolescents' diets and to provide a new psychological stress–focused conceptual framework for developing intervention strategies targeted at obesity prevention in adolescents. We begin by describing how parenting practices related to food, including family meals, parent dieting, and other parent-related food practices, influence the adolescent diet. After describing the pathways related to parenting practices around meals and eating, we discuss evidence for, and mediators of, an additional pathway through which parenting may increase unhealthy eating behaviors associated with obesity and cardiometabolic risk factors in adolescents: parental stress (Figure 1). Finally, we conclude this review with discussion of future directions for research on modifiable parental- and family-level factors that influence stress-related overeating and obesity in adolescents. In this review, the term *adolescent* refers to individuals 10–19 years of age. In some cases, studies are included with youth younger than 10 years, but only if the upper age-range of the sample size includes youth ages ≥10 years.

Stress is an important environmental factor that influences diet. Stress is broadly defined as any real or perceived threat to homeostasis, in which the brain integrates environmental signals to recognize threat and uses highly conserved, and learned, response mechanisms intended to return the individual to homeostasis and minimize damage.[11] Stress has been linked to obesity and associated noncommunicable cardiometabolic diseases,[12] and cardiovascular and metabolic risk factors such as endothelial dysfunction,[13] hypertension,[14] hyperglycemia,[15] and insulin resistance[16] are seen in increasingly younger populations.

Stress influences food choice and dietary habits that increase risk for development of these stress-related conditions.[11] Though stress has mostly been examined as a risk factor for poor diet in adults, adolescents may be particularly vulnerable to the effects of stress due, in part, to an imbalance during this developmental stage between brain regions associated with self- or emotional regulation and brain regions associated with reward and emotional reactivity.[17]

Adolescence is a critical developmental period, often defined as beginning with puberty and ending around age 19 years, characterized by rapid physical and cognitive development. It is a vulnerable period for onset of disordered eating behaviors, including emotional eating, bulimia, anorexia, and binge eating.[18] The adolescent period is an inherently stressful time of life marked by gradual acquisition of self-identity, cognitive and emotional maturity, and the skills necessary for independent living and for less dependence on the familial unit.[19] Importantly, stress-specific effects on the brain and body confer increased risk for mental and cardiometabolic dysfunction and food-related coping mechanisms.[20] For example, elevated cortisol increases blood glucose levels, mobilizes fatty acids and amino acids, favors visceral or abdominal adiposity, and promotes reward-based eating behavior and consumption of highly palatable, energy-dense foods.[11] Not only have metabolic and behavioral effects of stress been well documented in adults, but stress-motivated eating has been documented in adolescents as well, suggesting that these behaviors may begin relatively early in life and persist to adulthood.[21–23]

Stress-motivated eating is akin to emotional eating, characterized by eating palatable foods high in sugar and fat in response to negative emotions, rather than to hunger.[24,25] Emotional eating is a risk factor for binge eating disorder, defined as eating large amounts of food in a short time while experiencing loss of control during the episodes.[26] Studies have shown that the prevalence of emotional eating increases in adolescence,[22] and still other studies have shown that onset of binge eating disorder typically occurs in adolescence,[27] further highlighting the need to address factors in this population that contribute to food-related coping mechanisms that may contribute to obesogenic eating habits throughout adulthood.[28] Overall, exposure to stress may lead to poor eating habits in adolescents, which, in turn, can increase risk for obesity and obesity-related diseases.

A comprehensive, multicomponent approach to addressing obesity in young people has been recommended.[10] Successful programs typically have been behavior based,[29] designed in line with a theoretical framework.[29] Programs documenting successful outcome measures have incorporated a combination of nutrition education in schools, gardening and cooking, peer-to-peer education, and family involvement.[30–32] However, programs aimed at youth obesity have had mixed success overall,[33] and behavior-focused programs have had limited long-term success.[33] Programs aimed at adolescent obesity that can address additional aspects of an adolescent's social ecological environment, such as parenting, should be further examined.[34] Although adolescents have much more freedom to procure and select their own food than do children, adolescents still rely significantly on the parent for their food and models of food selection and eating patterns.[35] Parenting practices, such as making healthy foods available, modeling healthy eating behaviors, and setting

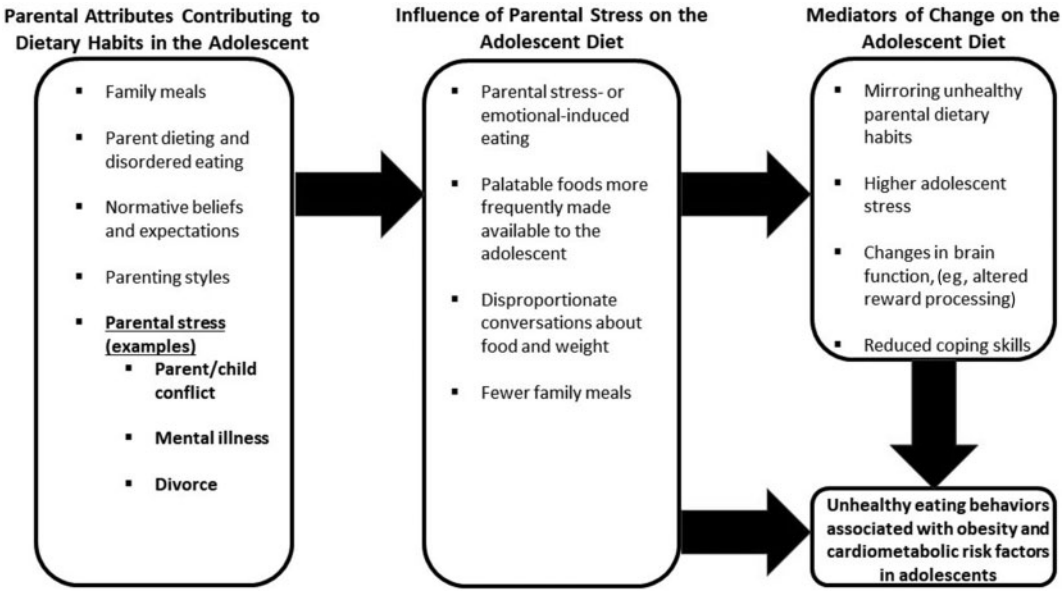

Figure 1 **Parental influence on the adolescent diet: a psychological stress–focused perspective**.

behavioral expectations, have been positively associated with youth diet quality.[36]

Given the profound influence the parent has on the adolescent in these behavioral areas, parental stress may also be a relevant environmental factor predictive of eating habits of young people. Interest in addressing the role of parent stress on youth obesity is increasing.[37–45] For example, in one study, researchers found that maternal perceived stress was inversely correlated with their childrens' Healthy Eating Index scores over 1 year.[42] Additional research exploring the role of parental stress in youth eating behaviors, stress, and diet quality may help establish novel pathways for increasing the development of healthy eating behaviors and healthy weight across the lifespan.

Influence of food-related parenting on adolescents' eating behavior

The parent is the most significant source of influence on eating behavior in youth, even in adolescents who seek increased independence and develop their own eating habits during independent eating occasions, usually in social settings with peers.[46] Although the influence of parents on the eating behavior of children encompasses prenatal, antenatal, and early childhood periods, these topics are beyond the scope of this review and are reviewed in detail elsewhere.[46–49] Parents create environments that can promote development of healthy eating habits in youth, and parents who set expectations, model healthy behaviors, and make healthy foods available typically buffer against obesogenic eating behaviors in their offspring.[36,50]

Influence of family meals and the home food environment

Family meals allow parents to control meal type, model appropriate eating behaviors, and implement food-related parenting practices.[35] Eating meals together positively influences diet quality in youth. High frequency of family meals has been associated with a greater sense of emotional well-being in adolescents,[51] which has been associated with lower risk of obesity, weight-controlling behaviors, and unhealthy eating habits.[52] Interestingly, in one study, frequent family meals in childhood were inversely related to stress and disordered eating behaviors in adolescence, an effect that seems to be mediated by coping skills and family cohesion.[53]

Although children may be more receptive to direct parental influence (eg, verbal encouragement) on decisions about eating behavior, adolescents seeking more independence during eating occasions may be more receptive to indirect parental influence, such as the parent making healthy foods available.[36] In addition, home environments fostering parent and adolescent involvement in food preparation are linked to better adolescent diet quality and a higher frequency of family meals.[54] Researchers examining adolescent involvement in food preparation found better diet quality in those who actively participated in food preparation for the family vs those who did not regularly participate.[55] Therefore, adolescents who prepare food for the family and participate in the family meal may be at lower risk for developing unhealthy, potentially obesogenic, eating behaviors.[56]

Parental dieting and disordered eating behavior can influence adolescents' eating behavior

Deliberately restricting food intake to promote weight loss, often referred to as restrained eating, is, in itself, a stressor, due to the mental exertion that this practice takes.[57] Restrained eaters are at higher risk of depression,[58] disordered eating,[59] and, notably, long-term weight gain.[60] Yet, youth as young as 5 years are aware of the concept of dieting,[61] and 46% of adolescents have attempted diet-induced weight loss,[62] despite the high nutritional demands for growth during this developmental period. Parents play a significant role in promoting or protecting their adolescents from dieting behaviors that may lead to unhealthy eating patterns and body weight. For example, parents who promote "thin or skinny ideals" may inadvertently encourage body dissatisfaction and repeated dieting attempts. Parental dieting behavior may also influence adolescents to adopt the parent's dieting habits, body concerns, and ideals of being thin. For example, a parent omitting carbohydrates or fat from their diet to lose weight may limit access to these important macronutrients and lead to a similar dieting strategy by the child.[63] Results from the Childhood Growth and Development study of 221 mother-child dyads showed that children of parents with a past or present eating disorder had higher rates of emotional eating and disordered-eating symptoms.[64,65]

Last, parental modeling of dieting constructs, such as dietary restraint, may influence their adolescent to engage in restrictive behavior as well, which is especially true in mother–adolescent daughter dyads.[66] Such modeling is a particular concern because dietary restraint is a potent predictor of disinhibited binge eating, defined as a tendency to overeat palatable foods, especially in the presence of stress.[67] Dietary restraint is also a predictor of long-term weight gain.[60,68,69] In one study, parental encouragement to diet affected adolescents when, 15 years later as parents themselves, they reported binge eating, engaging in behaviors to control weight, and engaging in weight-centric communication in their own homes.[70]

Parental influence on adolescents' independent-eating occasions

Eating provides an opportunity for recreation and socialization, the latter of which becomes increasingly important for teenagers. Adolescents spend significant time eating without parental supervision; examples include eating at convenience stores, friends' houses, and at restaurants. Yet, normative beliefs and expectations of the parent about best food-intake practices still have important influence on the eating habits of the adolescent even when not in the presence of the parent.[36] For example, beliefs and expectations of what constitutes a healthy diet and accepted eating habits can continue to influence the eating habits of the adolescent throughout their life. That is, the parent's ideas and models of food selection and intake may persist as the adolescent navigates their own food environment.[36]

Parental modeling and food-related parenting practices

In the Family Life, Activity, Sun, Health, and Eating study, researchers examined correlates of fruit and vegetable intake in 1859 US parent-adolescent dyads.[71] In this study, food-related parenting practices were in alignment with parents' own dietary behaviors, but the effects of food-related parenting practices on actual eating behavior in the adolescents were more complex. Encouraging fruit and vegetable (FV) consumption by the parent was positively related to FV consumption by the adolescent, but parent rules to avoid "junk" food and sugar-sweetened beverages were associated with greater consumption of these items by the adolescent. In another publication from the same study, FV consumption by adolescents was predicted by parent-adolescent joint decision making on availability of FV in the home and how much FV the adolescent should consume.[72] That study demonstrated that an authoritative parenting style high in expectations and warmth, which is characterized by love and compassion, positively influenced overall diet quality of the adolescent. Other parenting practices may have unintended effects. For instance, parents who restrict food or pressure their adolescent to eat may lead to eating behaviors in the adolescent that have the opposite effect or are detrimentally magnified.[48] Results of previous studies indicate restrictive or pressuring food-related parenting styles or strategies may result in disinhibited emotional eating in their children,[73] further corroborating other research suggesting that general parenting practices influence eating behaviors of adolescents. Setting inconsistent limits, being emotionally distant or overprotective, and using an authoritarian parenting style are considered risk factors for development of disordered eating in adolescents.[73]

On the other hand, mindful parenting, which is defined as a framework whereby parents bring intentional awareness, attentiveness, and nonjudgement to the parent-youth relationship,[74] has been inversely linked to adolescents' emotional eating. Another study[75] found that mindful parenting, especially encompassing compassion for the adolescent, may improve self-esteem

and subsequent emotional eating tendencies in adolescents.

INFLUENCE OF PARENTS ON EATING BEHAVIOR IN ADOLESCENTS: PARENTAL STRESS

Psychological stress may influence the style and intensity of food-related parenting practices, as well as eating habits of the parent. Considering the profound influence of the parent on adolescents' eating behavior, parental stress may, in some cases, contribute to emotional eating, especially comfort foods, in adolescents,[76] particularly those who are already experiencing stress.

Stress occurs on multiple levels and can be social, psychological, or physiological. Although interindividual differences in stress reactivity exist, the body's signature response to a recognized stressor typically includes activation of neuroendocrine negative feedback loops, a hallmark of which is the hypothalamic-pituitary-adrenal (HPA) axis. Activation of the HPA axis leads to increased circulating cortisol, a glucocorticoid hormone that promotes physiological arousal, mobilizes and redistributes peripheral energy stores to fight or flee perceived danger, and, through its negative feedback effects, extinguishes the HPA response after danger has passed.[77] Adaptations to chronic stress include hypo- or hyperactivity of the HPA axis, and a growing body of literature suggests that, at least in some individuals, chronic stress, possibly via altered cortisol activity, affects the brain, behavior, and nearly every peripheral organ system in ways that may increase risk for developing or sustaining metabolic disease.[17] Consumption of highly palatable foods dampens the stress response by altering brain pathways that trigger and coordinate cognitive, neuroendocrine, and behavioral responses to stress. Consequently, this negative feedback effect of consuming highly palatable foods is thought to reinforce lifelong eating habits that increase obesity risk.[78] Neuroendocrine circuits involved in energy balance and the stress response significantly overlap, which may explain how stress, metabolic dysfunction, and eating behavior are so tightly intertwined.[79] Although an in-depth discussion of neuroendocrine and neuropeptide mediators of eating behavior is beyond the scope of this review, the material has been extensively reviewed elsewhere.[79,80]

Evidence that parental stress influences adolescents' eating behavior

The climate of the parent-adolescent relationship influences the degree to which the adolescent responds to food-related parenting behaviors. According to Bandura's 1978 social learning theory, "children learn responses and behaviors that are modeled for them."[81] In this case, parents experiencing significant stress may model stressed behavior to their adolescent children who, in turn, may exhibit heightened stress responses or seek food as a coping mechanism to circumvent their own negative response to such stress. It is also possible that palatable food choices of a stressed parent are made available to their adolescent, thereby promoting obesogenic eating habits this way.

One necessary caveat that Epel and colleagues[82] have identified is the lack of consistency and lack of a gold standard of stress measurement. Therefore, the stressors described in this section may be attributed to other, unaccounted for health behaviors that are not precisely stress-driven. Because stress can be experienced on multiple levels (eg, social, physiological, and psychosocial), to move forward in this area requires more succinct definitions of stress and consistent measurement methods.[82] It also is difficult to disentangle the effects of specific stressors such as poverty, neighborhood violence, and racial discrimination, because these are often correlated; therefore, more research with diverse samples is needed to help disentangle these different forms of stress and specific pathways linking each form of stress to adolescent eating. Nonetheless, the studies described herein suggest that addressing stress in the parent-adolescent relationship may play an important role in promoting weight-related changes in adolescents. Research in this area could identify more complete mechanisms by which parental stress influences eating behavior in the adolescent.

Parental stress affects food-related parenting practices and adolescent anthropometric outcomes in parent-adolescent dyads. In one study, the number of parental stressors was directly linked to childhood (ages 3–17 years) obesity, and fast-food consumption, which can increase obesity risk.[38] The findings from this study are in agreement with other studies in which a higher level of parental perceived stress was predictive of an increased body mass index trajectory in preadolescents at follow-up.[83] Interestingly, in a cross-sectional study using a sample of Southern California residents, researchers did not find associations between parental perceived stress and adolescent waist circumference.[84] The authors commented that perceived stress over the past month (as measured by the Perceived Stress Scale) may dissipate too quickly to have an effect on obesity indicators in youth over the 1-year examination period.[84]

Authors of a prospective cohort study of parent-preadolescent dyads found that maternal exposure to stress was a risk factor for eating pathology symptoms in preadolescents.[64] Emotional eating in response to family stress may be a coping mechanism for

adolescents exposed to stressful events over time.[64] The researchers suggested that adolescents exposed to family stress during this life period may benefit from additional support to reduce risk of emotional or disordered eating, though more research is needed.

The nature of the parent-adolescent relationship may lead to a socioemotional, as well as a nutritional, climate that increases obesogenic eating behaviors in the adolescent. For example, parent-adolescent conflict is an important stressor that may contribute to stress-induced eating habits and adolescent obesity. The role of parent-adolescent conflict in predicting obesogenic eating habits of 51 adolescents and their parents was investigated in a recent study. Researchers[85] found that adolescents' perceived stress predicted obesogenic eating behaviors, including restrained eating, emotional eating, and external eating (ie, eating in response to external cues, such as viewing or smelling food). However, parent-adolescent conflict predicted only restrained eating, when controlling for adolescents' perceived stress.[85] Although the findings from this study are valuable in addressing an unexplored area in the literature, the researchers used adolescent reporting of parent-adolescent conflict and captured adolescents' perceived stress in domains inside and outside of the relationship. To better appreciate the origins of stress and how the parent-adolescent conflict links to adolescents' perceived stress and eating behavior, studies would benefit from also assessing parents' report of parent-adolescent conflict, in addition to capturing the parents' perceived stress. These measures would more fully capture stress in the parent-adolescent dynamic in relation to adolescents' obesity-promoting eating behaviors.

Results from another study indicated that parental rejection was associated with emotional eating in children between 11 and 15 years old.[76] These findings suggest that negative affect as a result of parental rejection may lead to emotional eating as a coping mechanism. Both studies highlight the potential role of a stressful parent-adolescent relationship in the development of emotional eating habits in the adolescent.[76]

Divorce is another stressful life event that causes familial upheaval and can cause tremendous stress for parents and children alike. In a study investigating divorce and obesogenic eating behaviors in preadolescents, researchers found that children of divorced parents consumed more sugar-sweetened beverages and ate breakfast less frequently than children of married parents.[86] Adolescent disordered eating secondary to emotional insecurity as a result of marital conflict in the home was investigated in another study.[87] The authors found that the influence of interparental discord on adolescents' emotional and behavioral development is a contributing factor to adolescent disordered eating patterns. Authors noted that marital conflict, along with other typical stressors during the adolescent period (eg, puberty and demands at school) may accentuate stress exposure, increasing risk for unhealthy behaviors such as disordered eating.[87]

Youth of parents with mental illnesses are also at higher risk of eating disorders. A biological predisposition may underlie this phenomenon; however, environmental factors may also contribute. Having a parent with mental illness can be stressful to the child, and children of a parent with a stress-related mental illness are also at greater risk for developing a stress-related mental illness (eg, major depression).[88,89] In sum, childhood exposure to a parent with mental illness may lead to higher levels of stress, which, in turn, may contribute to the onset of disordered eating by the child.[90]

In a study of a racial minority population of parents and their adolescents (11–19 years old), researchers explored the role of specific stressors on adolescent obesity in Black youth.[91] Here, parent stress related to safety in the community was positively associated with adolescent body mass index and waist circumference, even after controlling for sedentary time and moderate to vigorous physical activity. The authors commented that more research is needed to fully elucidate the mechanisms by which parent stress related to neighborhood safety influence adolescent obesity, beyond moderating factors such as parent promotion and sedentary indoor activities.

Weight-related conversations in parent-adolescent relationships may strongly influence the adolescent's body weight, exercise habits, and eating behaviors; however, the nature of the conversation can be helpful or harmful. For example, weight-based conversations that include a dialogue with children about avoiding weight gain and eating differently to lose weight may be distressing to teenagers who then incur greater risk of developing disordered eating habits and unhealthy weight gain.[92,93] This finding is in agreement with previous research also showing associations between weight-based conversations with parents and risk of weight-bias internalization, binge eating, and eating to cope with psychological distress in adolescents.[94]

The relationship between parental stress and adolescent obesity may be bidirectional. For example, parental stress and associated feeding practices may affect disordered eating in the child, or that child's disordered eating habits may affect parental stress and food-parenting practices.[95] George and colleagues[87] discussed the role a young person may play in contributing to a stressor such as marital conflict. In sum, there is behavioral evidence suggesting a link between parental stress and emotional eating by adolescents; however, the mechanisms explaining this relationship are less

understood. In the next section, we discuss potential mechanisms underlying the association between parental stress and adolescent diet.

POTENTIAL PATHWAYS EXPLAINING THE ASSOCIATION BETWEEN PARENTAL STRESS AND ADOLESCENT DIET

There are many potential pathways that could explain the association between parental stress and adolescent diet and body weight. Different environmental stressors can activate ubiquitous stress systems[82] that, if activated over time, can detrimentally affect the brain, eating behavior, and metabolism. The adolescent brain appears to be particularly vulnerable to stress exposure,[96] and in neuroimaging studies and review articles, researchers have demonstrated that stress exposure from multiple sources affects the vulnerable adolescent brain during this crucial stage of maturation.[97–101] In this section, we explore potential pathways by which parental stress may influence adolescent obesity (Figure 1).

Parental stress can influence parent eating and modeling of food-related behaviors

Stress and depressed mood in parents have been associated with unhealthy food-related parenting practices. For example, in a cohort of 202 mothers and their children (8–12 years old), the mothers' negative affect predicted unhealthy food intake (eg, pastries, sweets, and fast food) for themselves and their children.[41] Thus, targeting stressful affect and honing health-promoting coping skills are promising interventions to reduce unhealthy food intake.

Some unhealthy food-related parenting practices may result from, or may be associated with, feelings of stress.[102] For example, a highly stressed parent may use controlling or restrictive food-parenting practices or be more inclined to seek palatable foods, thus making available more convenient and less healthy foods to their children. In addition to stress and its relation to poor food-related parenting practices, individuals who consume palatable foods under stress demonstrate temporary stress reduction.[103] For example, parents experiencing stress or who are overwhelmed by responsibilities of child-rearing may turn to food as a reward or coping device. Such preferential selection of comfort foods may (1) mediate a poorly understood brain-metabolic negative feedback loop, and/or (2) meet the brain's increased energy demands and glucose allocation. In turn, this type of behavior may increase risk of unhealthy or obesogenic eating behaviors in the adolescent. Unfortunately, repeated stress-driven overconsumption in today's obesogenic eating environment may promote obesity and a vicious cycle of behavioral and metabolic abnormalities.[11]

Parental feeding practices affect underlying adolescent neurobiological functioning in response to food cues

Parental teaching and modeling of eating behavior have been associated with increased brain activation in visual and reward-associated areas of the brain in adolescents with obesity.[104] In the same study, heightened activation in visual processing areas, with saliency for restricted foods, were noted in a control group of adolescents of healthy weight who ranked parental feeding practices as restrictive. These findings demonstrate the influence of parental feeding practices on adolescents' neural responses to food.[104]

Although parental stress profoundly influences adolescents' diet, weight trajectories, and even brain structure and function, minimal or no studies, to our knowledge, have investigated the role of parental stress in adolescents' neural responses to food. More research in this area may help elucidate mechanisms by which parental stress is a risk factor for adolescent obesity.

Parental stress may lead to increased stress in adolescents

There is a large body of research demonstrating associations between parental stress and offspring stress. Although this literature is beyond the scope of this review, it has been reviewed elsewhere.[89,105,106] Overall, parents who experience stress may transmit stress to their adolescent through a variety of mechanisms (eg, insecure attachment, harsh or neglectful parenting, lack of emotion coaching and teaching of emotion regulation strategies). Parental stress may also modulate the adolescents' brain structure and function. Although many studies have looked at the association between adolescent brain function and a variety of stressors that are likely correlated with parental stress (eg, poverty, parental psychiatric disorders), fewer studies have directly examined the association between parent-reported subjective stress and adolescent brain structure or function. To our knowledge, Niehaus and colleagues[107] were among the first to have investigated the relationship between maternal stress and the adolescent brain. They examined mothers' reported stress and cortisol reactivity in relation to their adolescents' neural reactions to negative emotional stimuli in an functional magnetic resonance imaging experiment. In this study, perceived maternal stress predicted higher medial prefrontal cortex (mPFC) activation to negative emotional stimuli in the adolescent; the prefrontal cortex is a

region known to play a regulatory role in the stress response.[107] The authors commented that lower mPFC activity in these at-risk youth would be more intuitive because of its involvement in regulation of the stress response; however, overuse of the mPFC to self-regulate in response to maternal stress could explain these results. In addition, higher mPFC activation may be indicative of heightened stress reactivity and processing of maternal stress. The study showed the impact of parental stress on developing neurobiological processes in the adolescent, which could potentially contribute to psychopathology. This is a potential neurobiological mechanism for stress transmission from parents to adolescents, though more research is needed.

Stress is a risk factor for altered reward processing and weight gain in adolescents

Brain regions affected by stress are profoundly important in learning, memory, emotionality, and executive function, the last of which is a term that encompasses processes involved in goal-directed behavior, including attentional control, inhibitory control, planning, and decision-making.[108] Thus, it is not surprising that stress exposure in adolescence may affect behavior and dietary decision-making both immediately and throughout the lifespan. Parental stress may influence adolescent brain development in ways similar to these other stressors. Next, we review research examining the association between other forms of stress and adolescent brain response to food.

Dysfunction in the balance of activity between mesolimbic reward regions and the prefrontal cortex, some of the same regions affected by stress, has been associated with obesity.[109] This imbalance is particularly important to the adolescent brain, whose plasticity and nonlinear development of limbic and frontal regions may make the adolescent more vulnerable to emotional volatility and pronounced reward-seeking behaviors.[17,110,111] In other words, the adolescent brain matures in such a way that limbic-striatal regions mature more rapidly than frontal regions that mediate emotional control and decision-making. In a study related to eating behavior, adolescents showed lower prefrontal activation and higher striatal-limbic activation in response to high-calorie food images than did adults.[112]

Disinhibited eating behavior in adolescents with obesity is associated with lower volume in brain regions linked to executive function.[113] It has been proposed that insulin resistance may mediate, in part, these structural changes in the executive brain. Insulin resistance is often seen in individuals with obesity, which has been posited to detrimentally affect cognitive function.[114]

Another hypothesis is that individuals with obesity experience what is referred to as "reward-deficiency syndrome." In this condition, decreased dopamine concentration in reward-associated regions is thought to lead to weaker activation of brain reward circuits, which is compensated for by compulsive reward-driven behavior, such as overeating.[115] Other theories propose that obesity increases the anticipatory reward response to food, but decreases the rewarding value of the food itself.[116] Altered appetitive processing to food cues has been demonstrated in adolescents experiencing stress. Striatal-limbic brain activation in 43 adolescents, most of whom were Black, was investigated during stress and presentation of images of personally tailored favorite foods.[117] Researchers found significant activation in striatal-limbic regions but no significant prefrontal activation in response to stressful stimuli and favorite food-cue conditions. Furthermore, deactivation was observed in regions including the anterior cingulate cortex and motor cortices, which are both involved in inhibitory control during appetitive stimuli, suggesting a mechanism explaining adolescent vulnerability to reward-driven behavior in stressful contexts.

Stress may also enhance the link between excessive brain activation to reward and subsequent weight gain. A neuroimaging study examined adolescent stress, negative affect, reward-related neural functioning, and obesity.[118] Stressful life events were found to moderate the association between activation in the middle occipital gyrus (a brain region involved in attention and visuospatial processing) in response to consuming a milkshake, and future weight gain, such that more middle occipital gyrus activity predicted weight gain in those reporting more stressful life events.[118]

CONCLUSION

Evidence compiled herein provides a conceptual model by which parental stress can influence parenting behaviors and, subsequently, eating behavior and adiposity in the adolescent. This work also serves as a resource to guide researchers in this emerging area Adolescents are especially vulnerable to the effects of stress, which has been repeatedly linked to palatable food intake and obesogenic eating behaviors in some individuals.[11] Parents have the most influence on adolescents' eating behavior, even as the adolescent expresses more autonomy and engages more frequently in independent eating occasions.[36] These influences can lead to healthy behavioral patterns (eg, family meals, modeling healthy food choices, and preparing meals) or detrimental behaviors (eg, fixation on thinness, dieting, or using food as a reward). Stress experienced by a parent may determine the type of parental modeling chosen and can increase

stress in their children. Together, these factors may explain obesity-promoting eating behaviors in adolescents. A physiological basis underlying the transmission of these factors to adolescents' eating behavior has not been elucidated. However, a growing body of literature, described throughout this review, has reported on various behavioral and even neurobiological changes in adolescents of stressed parents. For example, adolescents may develop certain eating patterns as a way to cope with having a stressed parent. On the other hand, a parent engaging in stress-related unhealthy eating may more frequently make palatable foods available to their adolescent. Neuroimaging studies in humans have shown that the adolescent brain is uniquely susceptible to stress and to reward-seeking behaviors, due, in part, to an imbalance in the timing of brain development that favors enhanced maturation in brain regions associated with reward vs executive function.[19] There is a paucity of neuroimaging studies linking maternal stress to structural or functional changes in the adolescent brain, but authors of one such study suggested promising results and motivation for additional research.[118] There are no studies to our knowledge that link parental stress to neural activation patterns in response to food in adolescents.

Despite this review's strength as a resource for researchers in this emerging area, it is a narrative review that is not without limitations. For example, the inherent nature of a narrative review, as opposed to a systematic review or meta-analysis, means it does not include a comprehensive search of all papers in this area and, as such, represents a limited selection of articles that can address specific pathways proposed in the theoretical model.

Nonetheless, more research on the mechanisms linking parental stress to adolescent diet could identify nontraditional program interventions aimed at stress in the parent-adolescent milieu to target obesity prevention in adolescents. Succinct definitions of stress and precise measurement methods are needed for advancement in this area.[82] Once mechanisms through which parental stress influences adolescent obesity are fully elucidated in research, then interventions can be developed to target these mechanisms. One example of a potential intervention approach is mindfulness, involving conscious use of the prefrontal cortices, which can dampen more impulsive health behaviors, including stress-induced eating, and such is the foundation of mindfulness and meditative practices.[57] Mindfulness programs have shown efficacy in adult populations,[119] and emerging interest and evidence suggests efficacy in family-based mindful eating exercises in adolescent populations, as well.[120,121] In addition, family-based interventions aimed at encouraging family mealtimes and weight-neutral conversations are promising candidates.

Research is needed to examine whether higher levels of parental stress are associated with altered brain function in appetitive and reward-related regions of the adolescent brain and to determine the mechanisms that mediate these effects, such as higher perceived psychological stress in adolescents and increased cortisol reactivity and alterations in stress physiology. In sum, it is necessary to understand how stress in parents influences their adolescents' neurobiology, physiology, and behavior, which, in turn, promote obesogenic eating patterns.

Acknowledgments

Author contributions. S.M.D. drafted the manuscript and submitted the manuscript. J.R.S. and K.D.L. oversaw the writing process and edited the manuscript.

Funding. S.M.D. is supported by the US Department of Agriculture (USDA) National Institute of Food and Agriculture, National Needs Fellowship 2018–38420-27959. J.R.S. is supported by the USDA National Institute of Food and Agriculture Hatch project 1013485. This research was also supported with funding from USDA Agricultural Research Service project 2032–51530-025–00-D.

Declaration of interest. The authors declare no conflict of interest.

REFERENCES

1. Ogden CL, Carroll MD, Kit BK, et al. Prevalence of childhood and adult obesity in the United States, 2011-2012. *JAMA*. 2014;311:806–814.
2. Wahl R. Nutrition in the adolescent. *Pediatr Ann*. 1999;28:107–111.
3. O'Connor TG, Scheible K, Sefair AV, et al. Immune and neuroendocrine correlates of temperament in infancy. *Dev Psychopathol*. 2017;29:1589–1600.
4. Bhadoria A, Sahoo K, Sahoo B, et al. Childhood obesity: causes and consequences. *J Family Med Prim Care*. 2015;4:187–192.
5. An R, Yang Y, Hoschke A, et al. Influence of neighbourhood safety on childhood obesity: a systematic review and meta-analysis of longitudinal studies. *Obes Rev*. 2017;18:1289–1309.
6. Robinson TN, Banda JA, Hale L, et al. Screen media exposure and obesity in children and adolescents. *Pediatrics*. 2017;140:S97–S101.
7. McGuire S. Scientific report of the 2015 Dietary Guidelines Advisory Committee. Washington, DC: US Departments of Agriculture and Health and Human Services, 2015. *Adv Nutr*. 2016;7:202–204.
8. Banfield EC, Liu Y, Davis JS, et al. Poor adherence to US dietary guidelines for children and adolescents in the National Health and Nutrition Examination Survey population. *J Acad Nutr Diet*. 2016;116:21–27.
9. Neumark-Sztainer D, Story M, Perry C, et al. Factors influencing food choices of adolescents: findings from focus- group discussions with adolescents. *J Am Diet Assoc*. 1999;99:5–10.
10. Ruiz LD, Zuelch ML, Dimitratos SM, Scherr RE. Adolescent obesity: diet quality, psychosocial health, and cardiometabolic risk factors. *Nutrients*. 2019;12:43.
11. Adam TC, Epel ES. Stress, eating and the reward system. *Physiol Behav*. 2007;91:449–458.
12. Frayn M, Livshits S, Knäuper B. Emotional eating and weight regulation: a qualitative study of compensatory behaviors and concerns. *J Eat Disord*. 2018;6:23.

13. Montero D, Walther G, Perez-Martin A, et al. Endothelial dysfunction, inflammation, and oxidative stress in obese children and adolescents: markers and effect of lifestyle intervention. *Obes Rev.* 2012;13:441–455.
14. Brady TM. Obesity-related hypertension in children. *Front Pediatr.* 2017;5:197.
15. Reinehr T. Type 2 diabetes mellitus in children and adolescents. *World J Diabetes.* 2013;4:270–281.
16. Levy-Marchal C, Arslanian S, Cutfield W, et al.; Insulin Resistance in Children Consensus Conference Group. Insulin resistance in children: Ccnsensus, perspective, and future directions. *J Clin Endocrinol Metab.* 2010;95:5189–5198.
17. Somerville LH, Jones RM, Casey BJ. A time of change: behavioral and neural correlates of adolescent sensitivity to appetitive and aversive environmental cues. *Brain Cogn.* 2010;72:124–133.
18. Bartholdy S, Allen K, Hodsoll J, et al. Identifying disordered eating behaviours in adolescents: how do parent and adolescent reports differ by sex and age? *Eur Child Adolesc Psychiatry.* 2017;26:691–701.
19. Guyer AE, Silk JS, Nelson EE. The neurobiology of the emotional adolescent: from the inside out. *Neurosci Biobehav Rev.* 2016;70:74–85.
20. McEwen BS, Bowles NP, Gray JD, et al. Mechanisms of stress in the brain. *Nat Neurosci.* 2015;18:1353–1363.
21. Nguyen-Rodriguez ST, Unger JB, Spruijt-Metz D. Psychological determinants of emotional eating in adolescence. *Eat Disord.* 2009;17:211–224.
22. Jääskeläinen A, Nevanperä N, Remes J, et al. Stress-related eating, obesity and associated behavioural traits in adolescents: a prospective population-based cohort study. *BMC Public Health.* 2014;14:321.
23. Debeuf T, Verbeken S, Van Beveren ML, et al. Stress and eating behavior: a daily diary study in youngsters. *Front Psychol.* 2018;9:2657.
24. van Strien T, Bazelier FG. Perceived parental control of food intake is related to external, restrained and emotional eating in 7–12-year-old boys and girls. *Appetite.* 2007;49:618–625.
25. Yau YHC, Potenza MN. Stress and eating behaviors. *Minerva Endocrinol.* 2013;38:255–267.
26. Mathes WF, Brownley KA, Mo X, et al. The biology of binge eating. *Appetite.* 2009;52:545–553.
27. Marzilli E, Cerniglia L, Cimino S. A narrative review of binge eating disorder in adolescence: prevalence, impact, and psychological treatment strategies. *Adolesc Health Med Ther.* 2018;9:17–30.
28. Lazarevich I, Irigoyen Camacho ME, Velázquez-Alva MdC, et al. Relationship among obesity, depression, and emotional eating in young adults. *Appetite.* 2016;107:639–644.
29. Hoelscher DM, Evans A, Parcel GS, et al. Designing effective nutrition interventions for adolescents. *J Am Diet Assoc.* 2002;102:S52–S63.
30. Hayes D, Contento IR, Weekly C. Position of the Academy of Nutrition and Dietetics, Society for Nutrition Education and Behavior, and School Nutrition Association: comprehensive nutrition programs and services in schools. *J Acad Nutr Diet.* 2018;118:913–919.
31. Scherr RE, Linnell JD, Smith MH, et al. The Shaping Healthy Choices Program: design and implementation methodologies for a multicomponent, school-based nutrition education intervention. *J Nutr Educ Behav.* 2014;46:e13–e21.
32. Scherr RE, Linnell JD, Dharmar M, et al. A multicomponent, school-based intervention, the Shaping Healthy Choices program, improves nutrition-related outcomes. *J Nutr Educ Behav.* 2017;49:368–379.e1.
33. Weihrauch-Blüher S, Kromeyer-Hauschild K, Graf C, et al. Current guidelines for obesity prevention in childhood and adolescence. *Obes Facts.* 2018;11:263–276.
34. Lindsay AC, Sussner KM, Kim J, et al. The role of parents in preventing childhood obesity. *Future Child.* 2006;16:169–186.
35. Salvy SJ, Elmo A, Nitecki LA, et al. Influence of parents and friends on children's and adolescents' food intake and food selection. *Am J Clin Nutr.* 2011;93:87–92.
36. Reicks M, Banna J, Cluskey M, et al. Influence of parenting practices on eating behaviors of early adolescents during independent eating occasions: implications for obesity prevention. *Nutrients.* 2015;7:8783–8801.
37. Jastreboff AM, Chaplin TM, Finnie S, et al. Preventing childhood obesity through a mindfulness-based parent stress intervention: a randomized pilot study. *J Pediatr.* 2018;202:136–142. e1.
38. Parks EP, Kumanyika S, Moore RH, et al. Influence of stress in parents on child obesity and related behaviors. *Pediatrics.* 2012;130:e1096–e1104.
39. Dunton GF, Dzubur E, Huh J, et al. Daily associations of stress and eating in mother–child dyads. *Health Educ Behav.* 2017;44:365–369.
40. O'Connor SG, Maher JP, Belcher BR, et al. Associations of maternal stress with children's weight-related behaviours: a systematic literature review. *Obes Rev.* 2017;18:514–525.
41. Mason TB, O'Connor SG, Schembre SM, et al. Momentary affect, stress coping, and food intake in mother–child dyads. *Health Psychol.* 2019;38:238–247.
42. O'Connor SG, Huh J, Schembre SM, et al. The association of maternal perceived stress with changes in their children's Healthy Eating Index (HEI-2010) scores over time. *Ann Behav Med.* 2019;53:877–885.
43. Berge JM, Tate A, Trofholz A, et al. Momentary parental stress and food-related parenting practices. *Pediatrics.* 2017;140:e20172295.
44. Tate EB, Wood W, Liao Y, et al. Do stressed mothers have heavier children? A meta-analysis on the relationship between maternal stress and child body mass index. *Obes Rev.* 2015;16:351–361.
45. Gundersen C, Lohman BJ, Garasky S, et al. Food security, maternal stressors, and overweight among low-income US children: results from the National Health and Nutrition Examination Survey (1999-2002). *Pediatrics.* 2008;122:e529–e540.
46. Scaglioni S, De Cosmi V, Ciappolino V, et al. Factors influencing children's eating behaviours. *Nutrients.* 2018;10:706.
47. Hoffmann DA, Marx JM, Kiefner-Burmeister A, et al. Influence of maternal feeding goals and practices on children's eating behaviors. *Appetite.* 2016;107:21–27.
48. Savage JS, Fisher JO, Birch LL. Parental influence on eating behavior: conception to adolescence. *J Law Med Ethics.* 2007;35:22–34.
49. Power TG. Parenting dimensions and styles: a brief history and recommendations for future research. *Child Obes.* 2013;9(Suppl.1):14–21.
50. Scaglioni S, Salvioni M, Galimberti C. Influence of parental attitudes in the development of children eating behaviour. *Br J Nutr.* 2008;99:S22–S25.
51. Utter J, Denny S, Peiris-John R, et al. Family meals and adolescent emotional well-being: findings from a national study. *J Nutr Educ Behav.* 2017;49:67–72. e1.
52. Schnettler B, Grunert KG, Lobos G, et al. Maternal food-related practices, quality of diet, and well-being: profiles of Chilean mother-adolescent dyads. *J Nutr Educ Behav.* 2018;50:776–787.
53. Franko DL, Thompson D, Affenito SG, et al. What mediates the relationship between family meals and adolescent health issues? *Heal Psychol.* 2008;27:S109–S117.
54. Larson NI, Perry CL, Story M, et al. Food preparation by young adults is associated with better diet quality. *J Am Diet Assoc.* 2006;106:2001–2007.
55. Berge JM, MacLehose RF, Larson N, et al. Family food preparation and its effects on adolescent dietary quality and eating patterns. *J Adolesc Health.* 2016;59:530–536.
56. Neumark-Sztainer D, Larson NI, Fulkerson JA, et al. Family meals and adolescents: what have we learned from Project EAT (Eating Among Teens)? *Public Health Nutr.* 2010;13:1113–1121.
57. Dallman MF. Stress-induced obesity and the emotional nervous system. *Trends Endocrinol Metab.* 2010;21:159–165.
58. Stice E, Hayward C, Cameron RP, et al. Body-image and eating disturbances predict onset of depression among female adolescents: a longitudinal study. *J Abnorm Psychol.* 2000;109:438–444.
59. Neumark-Sztainer D, Wall M, Guo J, et al. Obesity, disordered eating, and eating disorders in a longitudinal study of adolescents. *J Am Diet Assoc.* 2006;106:559–568.
60. Lowe MR, Doshi SD, Katterman SN, et al. Dieting and restrained eating as prospective predictors of weight gain. *Front Psychol.* 2013;4:577.
61. Abramovitz BA, Birch LL. Five-year-old girls' ideas about dieting are predicted by their mothers' dieting. *J Am Diet Assoc.* 2000;100:1157–1163.
62. Eaton DK, Kann L, Kinchen S, et al. Youth Risk Behavior Surveillance — United States, 2011. Available at: https://www.cdc.gov/mmwr/preview/mmwrhtml/ss6104a1.htm. Accessed January 31, 2020.
63. Balantekin KN. the influence of parental dieting behavior on child dieting behavior and weight status. *Curr Obes Rep.* 2019;8:137–144.
64. Allen KL, Gibson LY, McLean NJ, et al. Maternal and family factors and child eating pathology: risk and protective relationships. *J Eat Disord.* 2014;2:11.
65. Watson HJ, O'Brien A, Sadeh-Sharvit S. Children of parents with eating disorders. *Curr Psychiatry Rep.* 2018;20(11):101.
66. Hill AJ, Weaver C, Blundell JE. Dieting concerns of 10-year-old girls and their mothers. *Br J Clin Psychol.* 1990;29:346–348.
67. Savage JS, Hoffman L, Birch LL. Dieting, restraint, and disinhibition predict women's weight change over 6 y. *Am J Clin Nutr.* 2009;90:33–40.
68. Wardle J, Steptoe A, Oliver G, et al. Stress, dietary restraint and food intake. *J Psychosom Res.* 2000;48:195–202.
69. Groesz LM, McCoy S, Carl J, et al. What is eating you? Stress and the drive to eat. *Appetite.* 2012;58:717–721.
70. Berge JM, Winkler MR, Larson N, et al. Intergenerational transmission of parent encouragement to diet from adolescence into adulthood. *Pediatrics.* 2018;141:2017–2955.
71. Fleary SA, Ettienne R. The relationship between food parenting practices, parental diet and their adolescents' diet. *Appetite.* 2019;135:79–85.
72. Parks CA, Blaser C, Smith TM, et al. Correlates of fruit and vegetable intake among parents and adolescents: findings from the Family Life, Activity, Sun, Health, and Eating (FLASHE) study.*Public Health Nutr.* 2018;21:2079–2087.
73. Zubatsky M, Berge J, Neumark-Sztainer D. Longitudinal associations between parenting style and adolescent disordered eating behaviors. *Eat Weight Disord.* 2015;20:187–194.
74. Duncan LG, Coatsworth JD, Greenberg MT. A model of mindful parenting: implications for parent-child relationships and prevention research. *Clin Child Fam Psychol Rev.* 2009;12:255–270.
75. Gouveia MJ, Canavarro MC, Moreira H. Is mindful parenting associated with adolescents' emotional eating? The mediating role of adolescents' self-compassion and body shame. *Front Psychol.* 2018;9:2004.

76. Vandewalle J, Mabbe E, Debeuf T, et al. The daily relation between parental rejection and emotional eating in youngsters: a diary study. *Front Psychol.* 2017;8:691.
77. Smith SM, Vale WW. The role of the hypothalamic-pituitary-adrenal axis in neuroendocrine responses to stress. *Dialogues Clin Neurosci.* 2006;8:383–395.
78. Dallman MF, Pecoraro N, Akana SF, et al. Chronic stress and obesity: a new view of "comfort food." *Proc Natl Acad Sci USA.* 2003;100:11696–11701.
79. Ulrich-Lai YM, Ryan KK. Neuroendocrine circuits governing energy balance and stress regulation: functional overlap and therapeutic implications. *Cell Metab.* 2014;19:910–925.
80. Maniam J, Morris MJ. The link between stress and feeding behaviour. *Neuropharmacology.* 2012;63:97–110.
81. Fryling MJ, Johnston C, Hayes LJ. Understanding observational learning: an interbehavioral approach. *Anal Verbal Behav.* 2011;27:191–203.
82. Epel ES, Crosswell AD, Mayer SE, et al. More than a feeling: a unified view of stress measurement for population science. *Front Neuroendocrinol.* 2018;49:146–169.
83. Shankardass K, McConnell R, Jerrett M, et al. Parental stress increases body mass index trajectory in pre-adolescents. *Pediatr Obes.* 2014;9:435–442.
84. Shonkoff ET, Dunton GF, Chou C-P, et al. Direct and indirect effects of parent stress on child obesity risk and added sugar intake in a sample of Southern California adolescents. *Public Health Nutr.* 2017;20:3285–3294.
85. Darling KE, Ruzicka EB, Fahrenkamp AJ, et al. Perceived stress and obesity-promoting eating behaviors in adolescence: the role of parent-adolescent conflict. *Fam Syst Health.* 2019;37:62–67.
86. Mauskopf SS, O'Leary AK, Banihashemi A, et al. Divorce and eating behaviors: a 5-day within-subject study of preadolescent obesity risk. *Child Obes.* 2015;11:122–129.
87. George MW, Fairchild AJ, Mark Cummings E, et al. Marital conflict in early childhood and adolescent disordered eating: emotional insecurity about the marital relationship as an explanatory mechanism. *Eat Behav.* 2014;15:532–539.
88. Hammen C, Shih J, Altman T, et al. Interpersonal impairment and the prediction of depressive symptoms in adolescent children of depressed and nondepressed mothers. *J Am Acad Child Adolesc Psychiatry.* 2003;42:571–577.
89. LeMoult J, Chen MC, Foland-Ross LC, et al. Concordance of mother-daughter diurnal cortisol production: understanding the intergenerational transmission of risk for depression. *Biol Psychol.* 2015;108:98–104.
90. Bould H, Koupil I, Dalman C, et al. Parental mental illness and eating disorders in offspring. *Int J Eat Disord.* 2015;48:383–391.
91. Allport L, Song M, Leung CW, et al. Influence of parent stressors on adolescent obesity in African American youth. *J Obes.* 2019;2019:1316765.
92. Berge JM, MacLehose RF, Loth KA, et al. Parent-adolescent conversations about eating, physical activity and weight: prevalence across sociodemographic characteristics and associations with adolescent weight and weight-related behaviors. *J Behav Med.* 2015;38:122–135.
93. Berge JM, MacLehose R, Loth KA, et al. Parent conversations about healthful eating and weight associations with adolescent disordered eating behaviors. *JAMA Pediatr.* 2013;167:746–753.
94. Puhl RM, Himmelstein MS. Weight bias internalization among adolescents seeking weight loss: implications for eating behaviors and parental communication. *Front Psychol.* 2018;9:2271.
95. Ventura AK, Birch LL. Does parenting affect children's eating and weight status? *Int J Behav Nutr Phys Act.* 2008;5:15.
96. Romeo RD. The teenage brain: the stress response and the adolescent brain. *Curr Dir Psychol Sci.* 2013;22:140–145.
97. Swartz JR, Williamson DE, Hariri AR. Developmental change in amygdala reactivity during adolescence: effects of family history of depression and stressful life events. *Am J Psychiatry.* 2015;172:276–283.
98. Tyborowska A, Volman I, Niermann HCM, et al. Early-life and pubertal stress differentially modulate grey matter development in human adolescents. *Sci Rep.* 2018;8:1–11.
99. Tottenham N, Galván A. Stress and the adolescent brain: amygdala-prefrontal cortex circuitry and ventral striatum as developmental targets. *Neurosci Biobehav Rev.* 2016;70:217–227.
100. Ho TC, Dennis EL, Thompson PM, et al. Network-based approaches to examining stress in the adolescent brain. *Neurobiol Stress.* 2018;8:147–157.
101. Busso DS, McLaughlin KA, Brueck S, et al. Child abuse, neural structure, and adolescent psychopathology: a longitudinal study. *J Am Acad Child Adolesc Psychiatry.* 2017;56:321–328. e1.
102. Gouveia MJ, Canavarro MC, Moreira H. How can mindful parenting be related to emotional eating and overeating in childhood and adolescence? The mediating role of parenting stress and parental child-feeding practices. *Appetite.* 2019;138:102–114.
103. Tomiyama AJ, Dallman MF, Epel ES. Comfort food is comforting to those most stressed: evidence of the chronic stress response network in high stress women. *Psychoneuroendocrinology.* 2011;36:1513–1519.
104. Allen HA, Chambers A, Blissett J, et al. Relationship between parental feeding practices and neural responses to food cues in adolescents. *PLoS One.* 2016;11:e0157037.
105. Young EA, Vazquez D, Jiang H, et al. Saliva cortisol and response to dexamethasone in children of depressed parents. *Biol Psychiatry.* 2006;60:831–836.
106. Bowers ME, Yehuda R. Intergenerational transmission of stress in humans. *Neuropsychopharmacology.* 2016;41:232–244.
107. Niehaus CE, Chaplin TM, Gonçalves SF, et al. Maternal stress and adolescent brain structure and function. *Brain Behav.* 2019;9:e01311.
108. Reising MM, Bettis AH, Dunbar JP, et al. Stress, coping, executive function, and brain activation in adolescent offspring of depressed and nondepressed mothers. *Child Neuropsychol.* 2018;24:638–656.
109. Gluck ME, Viswanath P, Stinson EJ. Obesity, appetite, and the prefrontal cortex. *Curr Obes Rep.* 2017;6:380–388.
110. Galvan A, Hare TA, Parra CE, et al. Earlier development of the accumbens relative to orbitofrontal cortex might underlie risk-taking behavior in adolescents. *J Neurosci.* 2006;26:6885–6892.
111. Casey BJ, Getz S, Galvan A. The adolescent brain. *Dev Rev.* 2008;28:62–77. doi:10.1016/j.dr.2007.08.003.
112. van Meer F, van der Laan LN, Charbonnier L, et al.; I. Family Consortium. Developmental differences in the brain response to unhealthy food cues: an fMRI study of children and adults. *Am J Clin Nutr.* 2016;104:1515–1522.
113. Maayan L, Hoogendoorn C, Sweat V, et al. Disinhibited eating in obese adolescents is associated with orbitofrontal volume reductions and executive dysfunction. *Obesity (Silver Spring).* 2011;19:1382–1387.
114. Convit A. Links between cognitive impairment in insulin resistance: an explanatory model. *Neurobiol Aging.* 2005;26(Suppl 1):31–35.
115. Blum K, Thanos PK, Gold MS. Dopamine and glucose, obesity and reward deficiency syndrome. *Front Psychol.* 2014;5:919.
116. Volkow ND, Wang GJ, Baler RD. Reward, dopamine and the control of food intake: implications for obesity. *Trends Cogn Sci.* 2011;15:37–46.
117. Hommer RE, Seo D, Lacadie CM, et al. Neural correlates of stress and favorite-food cue exposure in adolescents: a functional magnetic resonance imaging study. *Hum Brain Mapp.* 2013;34:2561–2573.
118. Yang X, Casement M, Yokum S, et al. Negative affect amplifies the relation between appetitive-food-related neural responses and weight gain over three-year follow-up among adolescents. *Neuroimage Clin.* 2019;24:102067.
119. Mason AE, Epel ES, Kristeller J, et al. Effects of a mindfulness-based intervention on mindful eating, sweets consumption, and fasting glucose levels in obese adults: data from the SHINE randomized controlled trial. *J Behav Med.* 2016;39:201–213.
120. Kumar S, Croghan I, Biggs B, et al. Family-based mindful eating intervention in adolescents with obesity: a pilot randomized clinical trial. *Children.* 2018;5:93.
121. Dalen J, Brody JL, Staples JK, et al. A conceptual framework for the expansion of behavioral interventions for youth obesity: a family-based mindful eating approach. *Child Obes.* 2015;11:577–584.