**SUPPLEMENTAL MATERIALS**

**Supplemental File 1. BIBLIOGRAPHY OF STUDIES INCLUDED IN THE REVIEW**

**Supplemental File 2. DETAILED SUMMARY OF STUDIES BY DEVELOPMENTAL PERIOD**

**Supplemental File 1. BIBLIOGRAPHY OF STUDIES INCLUDED IN THE REVIEW (*n* = 310)**

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**Supplemental File 2. DETAILED SUMMARY OF STUDIES BY DEVELOPMENTAL PERIOD**

## 1. Factors in the Prenatal–Infants Stage

1.1 Genetic influences

1.2 Maternal health

1.3 Prenatal child health

1.4 Temperament

1.5 Socioeconomic influences

## 2. Factors in the Toddlers–Preschoolers Stage

2.1 Nutrition and dietary intake

2.2 Physical activity and sedentary behaviors

2.3 Self-regulation

2.4 Rapid weight gain and adiposity rebound

2.5 Externalizing behaviors

2.6 Adverse events

## 3. Factors in the School Age Children Stage

3.1 Nutrition and dietary intake

3.2 Physical activity and sedentary behavior

3.3 Sleep

3.4 Self-esteem

3.5 Maternal mental health

**4. Factors in the Adolescents–Teenagers Stage**

**4.1 Nutrition and dietary intake**

4.2 Physical activity and sedentary behavior

4.3 Depressed mood

4.4 Perceptions of weight and body image

4.5 Corollary health behaviors

## 5. Parenting and Family Management

5.1 Parenting styles

5.2 Feeding practices

5.3 Parental modeling

5.4 Family functioning, relationship quality, and support

5.5 Positive behavior support

6. Distal Ecological Influences

**1. Factors in the Prenatal–Infants Period**

1.1 Genetic influences. A modest body of methodologically strong research supports genetic influences on weight. This section includes studies of twins, adoption, cross-generational, epigenetics, and neurotransmitters. Cross-generational genetic studies have shown that the weight status of grandparents and parents, particularly on the maternal side, are at least moderately predictive of childhood obesity. However, this line of research is in the early stages. The Lifeways cross-generational cohort study (*n* = 1128 families; Ireland) demonstrated the continuity of obesity across two and three generations (Kelleher et al., 2014; Murrin, Kelly, Tremblay, & Kelleher, 2012). Both maternal and paternal lines were associated with child height, but only the maternal line contributed to child BMI (Murrin et al., 2012). The X-linked effects and the mitochondrial DNA transmission from the grandparents and maternal genetic line and the Y-linked effects from the grandparents and father of the paternal genetic line play key roles in children’s weight status. In this way, multiple generations account for the differences in birth weight and the likelihood of the child developing a chronic disease in adulthood (Kelleher et al., 2014).

Certain nutrients, such as methionine, vitamins B6 and B12, and folate from the mother’s diet assist DNA methylation in utero, and mother’s FTO gene was strongly associated with the relation between maternal BMI and child adiposity (Kelleher et al., 2014). In a 38-year longitudinal birth cohort study (*n*  = 1037;New Zealand; 48% female; Dunedin Multidisciplinary Health and Development Study), higher risk at birth, as indicated by a genetic risk score composed of 32 single-nucleotide polymorphisms that was developed through previous genome-wide association studies, was associated with higher BMI at each assessment point from age 3 to 38 years. Previous genome-wide association studies led to the development of a quantitative index to assess an individual’s genetic risk score. Children with a higher genetic risk score grew faster through childhood, had earlier onset adiposity rebound, had a higher BMI across the 38 years of the study, and were at greater risk for obesity in adulthood. However, genetic risk was not associated with birth weight (Belsky et al., 2012).

In children, the metabolism of branched-chain amino acid is associated with obesity. Child overnutrition can lead to a higher concentration of branched-chain amino acid, which can lead to obesity (McCormack et al., 2013). Gene polymorphisms in one specific dopamine receptor, DRD2 rs1800497, predicted whether overweight children were responsive to a 1-year lifestyle behavior intervention (Roth, Hinney, Schur, Elfers, & Reinehr, 2013). However, another dopamine receptor, DRD4 VNTR, was not associated with BMI or intervention response (Roth et al., 2013). Relatedly, a serotonin transporter gene and a monoamine oxidase A gene were both associated with obesity and overweight for both males and females in the National Longitudinal Study of Adolescent Health (Add Health) (*n* = 3787) (Fuemmeler et al., 2009). However, the active form of the monoamine oxidase A promoter VNTR, in combination with depressive symptoms, decreased the risk for obesity among men only. This enzyme regulates dopamine, serotonin, and norepinephrine; dysregulation among these neurotransmitters affects energy, pleasure in food, and eating behaviors (Fuemmeler et al., 2009).

In a twin study conducted in Australia (*n* = 1143; *m[baseline]* = 12 years; monozygotic and dizygotic twin pairs), gender differences in additive genetics as it related to BMI were found. Additive genes code for the same trait, as in the case of eye color. For males, there was an input of additive genetic variance at age 12 that affected later BMI. For females, the additive genetic influence on BMI occurred at ages 12, 14, and 16. Further, non-additive genes played an important role in metabolism and adiposity distribution (Cornes, Zhu, & Martin, 2007). A study on genetic similarities in siblings from Add Health (*n[baseline]* = 5524; *m[baseline]* = 16.5 years, SD = 1.7; 50.3% female), the additive effect of genes, over environmental factors, accounted for one-third to one-half of the variance in weight status during adolescence (Nelson, Gordon-Larsen, North, & Adair, 2006).

1.2 Maternal health.In relation to childhood adiposity, maternal health has been studied primarily in the way that their weight predicts the weight of their child. The Lifeways cross-generational cohort study from Ireland (*n* = 1128) found that maternal self-reported a multi-component indicator of general health predicted their child’s birth weight (Kelleher et al., 2014). A study of 67 Mexican children, followed from 18 to 30 months old, found that maternal weight was related to child growth in toddlerhood through many factors such as genetics, household environment, and nutrition of the child in utero (Allen et al., 1992). In a study of urban preschool children in Vietnam (*n* = 526; *m* = 4-5 years at baseline), maternal overweight was predictive of the children’s weight status one year later (Huynh, Dibley, Sibbritt, Tran, & Le, 2011). This effect was especially strong when both parents were overweight. In an epidemiologic study of 1373 elementary-aged children (*m* = 5-10 years; 50% female) in Australia, maternal adiposity was the strongest indicator of the child having an elevated BMI, controlling for behavioral and environmental influences (Hesketh, Carlin, Wake, & Crawford, 2009).

Studies have also included parents’ eating habits and nutritional intake as a proxy indicator for their overall health. In a study of 168 non-Hispanic White girls in Pennsylvania (*m[baseline]* = 5.4 years, SD = 0.4), children and their parents were assessed for BMI and disinhibited eating (Francis, Ventura, Marini, & Birch, 2007). BMIs for girls with two overweight parents increased more rapidly from childhood until age 13, compared to girls with one overweight parent or parents with healthy weight. Further, mothers’, but not fathers’, eating patterns were associated with the girls’ disinhibited eating. A study using the 1946 British birth cohort (*n* = 5362; 47.5% female) was conducted to analyze the effects of socioeconomic status and obesity on type 2 diabetes. It is well documented that in utero, changes in glucose and insulin metabolism due to the mother’s dietary choices contribute to low birth weight, but there is less evidence regarding the association between birth weight or adiposity rebound and type 2 diabetes (Wadsworth, Butterworth, Marmot, Ecob, & Hardy, 2005).

Although not identifying the direct relation to child weight, one study highlighted the importance of understanding how maternal age might be related to their health status, and consequently to child weight. A study in the US on the health status of young adult parents and nonparents (100 female parents, 738 female nonparents, 49 male parents, 633 male nonparents; *m* = 25 years; Project EAT) indicated that younger mothers have more negative health outcomes, such as poor diet quality and higher BMI, compared to their nonparent counterparts. However, this relationship was not significantly different for fathers (Berge, Larson, Bauer, & Neumark-Sztainer, 2011).

1.3 Prenatal child health.The literature on the effects of prenatal child health on later weight is limited as much of the research in this area concerns the relation of parental health and child weight. Most of the studies identified through our search found stronger associations between maternal BMI and later child BMI than any other in utero factors. Preterm infants with prenatal exposure to drugs and alcohol were not found to have higher rates of obesity at age 11 than the estimated nationally average child in a study of 1388 infants in the US (Gaskins et al., 2010). However, maternal BMI before pregnancy was associated with higher obesity at age 11. In a study of 1373 Australian children (50% female), whether or not the mother smoked during pregnancy did not predict childhood overweight, but smoking did contribute to a increases in BMI *z*-scores over three years (Hesketh et al., 2009). Again, maternal BMI was the strongest predictor of a change in the child’s BMI. In a Norwegian study of the relationship between mother and father BMI with offspring BMI (*n* = 29,216), the researchers did not find a significant difference between the relationship of maternal BMI to offspring BMI and the relationship of paternal BMI to offspring BMI when parental BMI was measured before and after pregnancy (Fleten et al., 2012).

Research focused on diabetes and related factors was another common source of literature on prenatal child health. In a subsample of the Birth Cohort of the Early Childhood Longitudinal Study (ECLS-B), a nationally-representative longitudinal study in the US concerning the predictors of obesity in kindergarten (*n* = 6800; *m[at kindergarten]* = 5.7 years, SD = 0.01; 48.8% female), maternal gestational diabetes was associated with three times the odds of child obesity (Flores & Lin, 2013). The Diabetes Autoimmunity Study conducted in the US (*n* = 1178; *m* = 6.59 years, SD = 3.10; 47.3% female) found that female gender, diabetes exposure in utero, and larger gestational size contributed to higher childhood BMI (Lamb et al., 2010). Additionally, evidence was found to suggest that the link between diabetes exposure and BMI was mediated by gestational size. Relatedly, the effect of maternal dietary choices during pregnancy on child weight has also been examined. In Sweden, parents of 10,762 infants (recruited prenatally) completed questionnaires before leaving the hospital after delivery and then again at the infant’s first birthday. Greater maternal intake of sweets during pregnancy, as well as having older siblings and older maternal age, were associated with greater frequency of child intake of sweets (Brekke, van Odijk, & Ludvigsson, 2007).

1.4 Temperament.A recent systematic review of the literature that included 13 longitudinal and five cross-sectional studies supports the relationship between infant temperament and subsequent weight gain (Bergmeier, Skouteris, Horwood, Hooley, & Richardson, 2014). Infants perceived by their mothers as “difficult” consistently demonstrated greater or more rapid weight gain in the first year of life. Other traits of the “difficult” temperament, such as distress to limitations, extraversion, and emotionality, were also positively associated with weight gain during infancy. A few studies also identified maternal feeding practices as a potential mediator between infant temperament and weight gain during preschool years. Our search yielded one birth cohort study of infant temperament. Mother-reported fussiness in infancy was positively associated with later body composition, energy intake, and activity levels in a sample of 30 infants (100% White; 53% female) in the UK (Wells et al., 1997). Specifically, infants who were easily soothable at 12 weeks old had leaner skinfold thickness (a measure of body fat distribution) and greater activity levels in toddlerhood (*m* = 2-3.5 years); in contrast, fussiness predicted greater intake of carbohydrates in toddlerhood after controlling for confounding variables such as skinfold thickness and percent body fat at baseline.

1.5 Socioeconomic influences. Socioeconomic status (SES) is commonly determined by such indices as household income or parental education. However, there are many factors that contribute to and are related to SES, such as race/ethnicity. The multifaceted nature of SES contributes to the complexity of findings related to obesity. A recent international review of overweight and obesity in preschoolers discussed the complicated nature of the relationship between SES and obesity (Quelly & Lieberman, 2011). Some studies reported that higher SES was associated with higher overweight incidences, while others found the opposite relationship. Race, parental education, income, and location confound the relationship in some studies. As an example, in a study that followed children from birth to 2 years old (*n* = 82; 100% White; 50% female), family income was negatively associated with body weight while parental education was not, when analyzed separately (Stunkard, Berkowitz, Schoeller, Maislin, & Stallings, 2004). Based on a systematic review of factors in childhood that contribute to adult obesity, Parsons et al. (Parsons, Power, Logan, & Summerbell, 1999) and Power and Parsons (Power & Parsons, 2000) summarized the effects of SES during childhood on obesity later in life: people born into low SES households were more likely to be obese in adulthood compared to their counterparts in high SES households. These findings align with those of Lane et al. (Lane, Bluestone, & Burke, 2013), who found that children (*n* = 917) from 10 cities in the US who were born into a low SES family, as measured by family income, were more likely to be overweight and continue to increase in BMI over time up to age 1, and the results of a birth cohort study of the differences between social class and child overweight (*n* = 9057; 49.3% female; Child Benefit Register for the Republic of Ireland), which found that from birth to 9 months, children’s rapid growth (unexpected infant weight gain beyond the normal weight range for that age) from the lower SES class was influenced most by post-birth maternal smoking and alcohol use and higher SES class children’s rapid growth was most influenced by breastfeeding practices (Layte, Bennett, McCrory, & Kearney, 2014). The results are not consistent across studies and samples, however. For example, in Vietnam where poverty rates are high, Huynh et al. (Huynh et al., 2011) found that children (*n* = 526; *m[baseline]* = 5.2 years, SD = 3.6 months; 51.1% female) from wealthier families had higher BMIs over time compared to children from poor families (Huynh et al., 2011). In addition to direct relationships between SES and weight-related outcomes, research has shown that SES affects other variables that are empirically related to obesity, such as children’s dietary intake and nutrition, breastfeeding, and food security. In this section, we discuss the findings related to different dimensions of the broader construct of SES and the way they are related to other variables in our cascade model, discussed in detail in later sections of this paper.

Concerning nutrition and SES, Canadian mothers (*n =* 2103; *m[baseline]* = 5 months; Longitudinal Study of Child Development in Quebec) were more likely to follow breastfeeding recommendations if they were older, more educated, and had a higher SES (Dubois & Girard, 2003). Further, children in high SES families were 2.3 times more likely to be fed according to infant nutrition recommendations, such as breastfed at birth, introduction to others foods at 4 months old or later, and cows’ milk at 9 months old or later, compared to children from low-SES families. Children with highly educated mothers were also 2.7 times more likely to be given nutrition in accordance with these guidelines than children with lower educated mothers. Additionally, children with mothers age 35 years or older were 3.7 times more likely to be fed according to the guidelines compared to children of mothers 24 years of age or younger. When these three SES variables were combined, children in the most privileged category were more than 8 times more likely to be given nutrition in accordance with these recommendations than children in the least privileged situation. In a birth cohort study conducted in Germany, children who were bottlefed, were from low SES households, had mothers who smoked during pregnancy, and had mothers who were overweight were more likely to be overweight from birth to six years old (*n* = 480, German Multicenter Atopy Study)(Bergmann et al., 2003).

When race/ethnicity was used as a proxy for SES, associations with overweight and obesity have been reported. In a study using data from ECLS-B (*n* = 6800; *m[baseline]* = 5.7 years; 48.8% female), researchers found that children of Latino and multiracial ethnicities were more than twice as likely to be severely obese in kindergarten than White children (Flores & Lin, 2013). In a study of behavior patterns and obesity (*n* = 8840; Add Health), White adolescents were more likely to participate in school clubs and sports, have higher parental education, have higher family income, and were less likely to be obese compared to other clusters, such as the sedentary behaviors cluster, which consisted of adolescents who were more likely to be from lower SES households (Boone-Heinonen, Gordon-Larsen, & Adair, 2008). In a study of low-income African American adolescent mothers (*n* = 118; *m[baseline]* = 16.3 years), 57% were overweight or at risk for overweight after giving birth (Black et al., 2006). There was no comparison condition.

Parental education is commonly used as a proxy for SES in studies related to child BMI. In a review of publications from ALSPC, lower maternal education was strongly associated with never breastfeeding and not following dietary recommendations (Emmett & Jones, 2014). In many studies, SES was controlled for rather than an explicit predictor of weight status. Among children from low SES families, defined by maternal education level, in the Resilience for Eating and Activity Despite Inequality (READI) study in Australia (*n* = 216; *m[baseline]* = 9.1 years; 56% female), improved dietary quality was associated with decreased BMI in children who were overweight at baseline but not in children who were normal weight (Lioret et al., 2014). In a study using data from the KOALA Birth Cohort Study (KOALA) (*n* = 1828; *m[baseline]* = 60.2 months; 48.7% female), four lifestyle patterns of children’s eating and activity behaviors were identified: television-snacking, sports-computer, traditional family, and fast food eaters (Jessica S. Gubbels, Kremers, Stafleu, et al., 2012). Parental education was related to three of the four patterns: higher maternal and paternal levels of education were associated with lower levels of the television-snacking pattern; high paternal education was related to lower levels of both the sports-computer and traditional family patterns; and low paternal education was associated with lower levels of the sports-computer pattern. In the All Babies in Southeast Sweden study (*n* = 10,762; *m[baseline]* = 9–18 months; 48.1% female), higher parental education was associated with lower frequency of sweets or pastries intake in infants and mothers’ education specifically was negatively correlated with the introduction of sugar-sweetened beverages before 240 days post birth (Brekke et al., 2007). Low parental education, African American or American Indian, parent overweight/obese, and smoking tobacco between grades 7 and 12, were related to higher BMI in females when measured in early adulthood (*n* = 6378; 50.7% female; Add Health) (Crossman, Sullivan, & Benin, 2006). The same relationships were not found in males.

A few studies have focused on the positive impact of high maternal education on reducing BMI. In the Mexico Collaborative Research Support Program (*n* = 67; *m[baseline]* = 18 months; 52.2% female) children of literate mothers, measured by the ability to read and/or write, had higher growth rates of weight and length than children of illiterate mothers up to age 30 months due to better quality diets served to the child (Allen et al., 1992). The same relationship was found for a general measure of SES. In KOALA (*n* = 2396; *m[baseline]* = 7 months; 48.5% female), infants in daycare had a greater increase in BMI from age 7 months to 2 years than those in at home care (Gubbels et al., 2010). Not surprisingly, children with mothers who had low levels of education were more likely to have their children in daycare than children in higher SES households.

Low food security is both the lack of available food and the perception of lacking food. It is often accompanied by hunger, which characterizes very low food security. A review of food security and obesity found that the relationship between these two constructs is unclear in children because the findings are confounded by age, race, family income, and sex. For women, however, the association between low food security and higher rates of obesity is more robust (Dinour, Bergen, & Yeh, 2007). The relationship between low SES and obesity is clearer in women than in men with women from low food security households (without hunger) being more likely to be overweight than women from households with high food security (Drewnowski & Specter, 2004). Low and very low food security are associated with lower-income levels and racial minority status in the US to the extent that low and very low food security are almost nonexistent in families with higher income levels. Metallinos-Katsaras, Must, and Gorman (2012) conducted a large, longitudinal study in the US (*n* = 28,353; *m[baseline]* = 3.1 years; 41.4% non-Hispanic White, 20.6% non-Hispanic Black, 31.6% Hispanic, 6.5% Asian; 49.9% female) and found that higher BMI during childhood was associated with retrospective reports of low food security during infancy (Metallinos-Katsaras et al., 2012). Maternal overweight and obesity amplified this relationship.

## 2. Factors in the Toddlers–Preschoolers Stage

2.1 Nutrition and dietary intake.There is an extensive literature on the dietary habits of toddlers and young children (up to age 10 years) with large, representative samples. Child dietary habits encompass many factors that can contribute to obesity, including nutritional quality of food consumed and eating behaviors. The quality rather than the quantity of food was found to be more influential to length and weight growth from 18–30 months, and diets higher in animal products were associated with heavier and taller toddlers, as shown in a study of the diets of young children in Mexico (Allen et al., 1992). Higher protein intake at ages 1 and 2 years was related to a higher chance of overweight at age 5 and a higher BMI at age 8 in a longitudinal study of 70 White children (47% female) in the US recruited in infancy (Skinner, Bounds, Carruth, Morris, & Ziegler, 2004). In a study of 203 healthy children (48.5% female) from DONALD, an open cohort study in Germany, girls who had consistent recommended levels of protein intake from age 1 to 2 years had higher BMIs than girls who had inconsistent protein intake. This was not found among boys (Gunther, Buyken, & Kroke, 2006). In a second study using data from the same sample, two critical periods (birth to 12 months and 5 to 6 years) were identified where higher levels of protein intake influence later obesity (Guenther, Remer, Kroke, & Buyken, 2007). In a prospective, population-based, longitudinal birth cohort study of 10,762 children in Sweden, greater sugar intake at age 1 year was associated with high-fat food consumption (Brekke et al., 2007). A study of African American preschoolers recruited between ages 3–5 years in Detroit, MI (51.6% female) found that excess consumption of sugar-sweetened beverages was significantly associated with obesity risk whereas energy-dense food consumption protected the children against obesity; however, children who consumed energy-dense foods were also found to be more physically active (Lim et al., 2009).

In a prospective longitudinal study of 40 infants of obese mothers and 38 infants of mothers with an average BMI (50% female), energy intake was a stronger predictor of body size than energy expenditure in toddlers (Stunkard et al., 2004). A longitudinal study of 130 Hispanic children in the US between the ages of 4 and 19 who were overweight for age and gender (*m[male]* = 11.2 years, *m[female]* = 10.7 years) analyzed the fat, fiber, energy density, and macronutrient content of children’s diets using 24-hour recall. The only statistically significant effect on BMI was for dietary fat intake (Butte et al., 2007). In a study of 682 children from ALSPC, a prospective birth cohort study, 7-year-old children with high dietary energy density had higher adiposity at age 9 years (Johnson, Mander, Jones, Emmett, & Jebb, 2008). Children who ate more fruit and drank fewer sugary beverages were less likely to be severely overweight in kindergarten according to a study of 6800 children (49% female) from ECLS-B (Flores & Lin, 2013).

Children who snack while watching television are at greater risk for obesity when compared to children who eat with their families according to studies of KOALA conducted in the Netherlands (*n* = 2074; *m* = 5 years; 48.7% female) (Gubbels, Kremers, Goldbohm, Stafleu, & Thijs, 2012; Gubbels, Kremers, Stafleu, et al., 2012). For children age 4 to 5 years, but not children age birth to 1 year, the relationship between television viewing and BMI was found to be mediated by dietary intake in a study of 9064 children (*m[recruitment]* = 0–1 and 4–5 years) in a nationally-representative, longitudinal study in Australia (Fuller-Tyszkiewicz, Skouteris, Hardy, & Halse, 2012). Girls as young as 5-years-old were found to be able to exhibit dietary restraint behaviors, or the ability to intentionally limit the amount of food eaten, which was positively related to BMI and negatively related to dietary intake. These patterns are consistent with the literature on dietary restraint in adults (Shunk & Birch, 2004).

2.2 Physical activity and sedentary behaviors.The literature on physical activity in toddlers and young children is limited compared to that conducted with older children and adolescents. Among the studies we identified that included young children, there are both basic epidemiology designs and studies of intervention programs aimed at increasing physical activity. A review paper of published longitudinal studies concluded that the earlier children cease or limit exercise, the more difficult it is to implement successful interventions for excess weight gain later in life (Parizkova, 2014). A study using a subsample (*n* = 470; *m* = 4-5 years; 50.8% female) from KOALA, found gender differences in the association between type of physical activity and BMI (Remmers et al., 2014). More vigorous physical activity was associated with greater decreases in BMI over time for heavier males and females; light physical activity was also associated with a decrease in BMI for heavier males; moderate to vigorous physical activity was associated with a decrease in BMI for normal weight males. A second study from a subsample of KOALA (*n* = 2074; *m* = 5 years; 48.7% female) found that children who are both highly physically active and highly sedentary are more likely to gain weight compared to children with high physical activity and low sedentary behavior (Gubbels, Kremers, Goldbohm, et al., 2012). Further, these patterns were related to parental education levels and parent’s BMI. In a third study of this KOALA subsample, physical activity in general was not associated with any of the energy balance-related identified behavioral eating patterns (e.g., ‘sedentary-snacking’, ‘healthy intake’, ‘sandwich’, ‘sporty-traditional’). Specifically, the ‘sedentary snacking’ pattern was related to growth in BMI over time. However, some specific types of child activities were related to these patterns, such as TV viewing with sedentary snacking and involvement in sports ( Gubbels, Kremers, Goldbohm, et al., 2012).

2.3 Self-regulation. Poor self-regulation and related constructs such as child temperament, self-control, inhibitory control, and impulsivity, are generally associated with obesogenic risk factors. According to a systematic review of the literature, poor dietary self-regulation was specifically identified as a risk factor for pediatric obesity and the relationship between early temperament and unhealthy weight gain appears to remain stable over time (Bergmeier et al., 2014). A recent meta-analytic review involving 3898 participants (*m* = 2-21 years, average 10.99 years) from 23 studies found a moderate effect (*g* = 0.406) of the relationship between higher impulsivity in children who are overweight/obese compared to healthy weight (Thamotharan, Lange, Zale, Huffhines, & Fields, 2013).

In a sample of 201 Australian children ages 2 to 5 (57.7% female), mothers’ reports of greater child temperamental difficulty, including level of cooperation, irritability, and approach behavior, were associated with less food fussiness approximately one year later (Bergmeier et al., 2014). Although difficult temperament was not associated with BMI over time, the authors suggest that less food fussiness may impact the child when his or her growth rate decelerates due to associations with increased caloric and carbohydrate intake. In a study of 57 children (67% Caucasian, 27% African American; 44% female) obtained from three cohorts, self-regulation skills were measured by clinician ratings of videotaped frustration and delay of gratification tasks (Graziano, Calkins, & Keane, 2010). Emotion regulation at age 2 was predictive of changes in BMI at age 5; however, children with *both* poor emotion regulation and low inhibitory control at age 2 were more likely to be classified as overweight or at risk at age 5. Similarly, 1061 children (80% White, 13% Black; 48% female) participated in a video-recorded “waiting game” and delay of gratification tasks at age 3. Height and weight were measured at ages 5, 7, 9, 11, and 12. Children who demonstrated low behavioral self-control at age 3 and poor delay of gratification at age 5, assessed using age-appropriate “waiting game” tasks, gained significantly more weight by age 12 than children who were either high in regulation on both tasks or low on the delay of gratification task only (Francis & Susman, 2009), further implicating self-control in toddlerhood as an obesogenic risk factor.

In a sample of 161 non-Hispanic White girls and their parents, lower inhibitory control at age 7 predicted higher BMI and greater weight gain between ages 7 and 15 (assessed at ages 7, 9, 11, 13, and 15) (Anzman & Birch, 2008). Among 844 adolescents (77% White, 12% Black, 6% Hispanic; 50% female), those who were rated higher by both teachers and parents on a measure of self-control at age 9 were less likely to be overweight at age 15 (Tsukayama, Toomey, Faith, & Duckworth, 2010). Those who were overweight at age 15 were one-half standard deviation lower than same-aged peers on self-control at age 9. In a rare study of mediation, self-regulation mediated the association between cumulative risk exposure (e.g., poverty, living conditions, family stress) at age 9 and BMI at age 13 in a sample of 244 children (97% Caucasian; 45% female) recruited from low-income families in rural counties of upstate New York (Evans, Fuller-Rowell, & Doan, 2012).

2.4 Rapid weight gain and adiposity rebound.A recent meta-analysis involving 47,661 participants from 10 cohort studies in 6 developed countries found that rapid weight gain during infancy (age birth–1 year) was predictive of a two-fold increase in risk of obesity in childhood (ages 6 to 14 years) and 23% higher risk in adulthood (Druet et al., 2012). Among our search results, a higher birth weight for gestational age and more rapid weight gain in infancy was predictive of higher BMI in childhood among a sample of 1178 children (72.1% non-Hispanic White; 47.3% female) with a genetic risk factor for developing type 1diabetes recruited from the Denver, CO metropolitan area (Lamb et al., 2010). Higher BMI between 8 and 43 months, weight gain in the first year, and birth weight were associated with increased risk for obesity at age 7 for 909 children from a larger birth cohort study of 8234 children (49% female; ALSPC) conducted in the UK ( Reilly et al., 2005). Data analysis from a subsample of 9057 typically-developing children (49% female) from a birth cohort study in Ireland indicated higher dietary quality, lower maternal BMI, and less TV viewing were associated with lower odds of rapid weight gain between 9 months and 3 years (Layte et al., 2014). In a number of studies, a longer breastfeeding duration was found to reduce the odds of rapid weight gain (Karaolis-Danckert, Guenther, Kroke, Hornberg, & Buyken, 2007; Lamb et al., 2010; Layte et al., 2014) and one study, a nationally-representative prospective longitudinal cohort study in Ireland (*n* = 11,134; 49% female), indicated that rapid weight gain mediated the relationship between longer breastfeeding duration and higher BMI in childhood (Layte et al., 2014). In ECLS-K (*n* = 5380; children from 310 schools), the school environment during kindergarten and first grade was found to inhibit rapid weight gain compared to the summer vacation period (von Hippel, Powell, Downey, & Rowland, 2007). Further, compared to Whites, Black and Hispanic children had higher gains during summer vacation but not during the school year (von Hippel et al., 2007).

Rapid weight gain is related, in part, to adiposity rebound, which is a developmental process where children's BMI typically increases during the first year of life, followed by a gradual decrease until it reaches the lowest point around 6 years of age, before increasing (rebounding) again. Studies in our search suggest that earlier adiposity rebound is associated with a higher gross weight around ages 3 to 4 years (Eriksson, Kajantie, Lampl, Osmond, & Barker, 2014; Williams, 2005). A study of a subsample of the Dunedin Multidisciplinary Health and Development Study—a longitudinal cohort study in New Zealand—found that adiposity early rebound predicted growth in BMI from age 3 to adolescence and persisting into adulthood (age 26) compared to average or later rebound (Williams & Goulding, 2009). Further, the Fels Longitudinal Study (n = 855; 49% female) found a historical lowering of the age of adiposity rebound, based on BMI growth curves from age 2 to 18 years, that corresponded with the worldwide obesity epidemic and is characterized by lower BMI before rebound and a more rapid growth in BMI afterwards ( Johnson et al., 2012). In a nationally-representative birth cohort study (*n* = 249; *m* = 1-5 years; 51.4% female; subsample of the Dortmund Nutritional and Anthropometric Longitudinally Designed Study [DONALD]), the rate of growth between birth and onset of adiposity rebound was found to differ by social class of the family, with children of parents with lesser skilled jobs were born lighter but were heavier at age 3 compared to a group of parents with skilled professional jobs and increase when children experienced longer breastfeeding (Layte et al., 2014). In a second study from this dataset, higher fat intake during the second year of life inhibited the decrease in body fat percentage typically seen just prior to adiposity rebound (Karaolis-Danckert et al., 2007). Last, a birth cohort study in Helsinki, Finland between 1934 and 1944 (*n* = 2877; 49.3% female) included birth size, maternal body size, SES, and body measurements from birth to 11 years old as variables to estimate the age of adiposity rebound. Earlier adiposity rebound was associated with a small head circumference, but not other measurements of birth size, and also with high maternal BMI and height. The study’s authors theorized that this was because children of mothers of greater height and weight grow more quickly at the beginning of pregnancy, so they are more likely to be undernourished in the last stage of pregnancy and then have to play catch-up once they are born, leading to earlier adiposity rebound (Eriksson et al., 2014).

2.5 Externalizing behaviors.The longitudinal relations between externalizing behaviors and weight appear to begin in and be most salient in the toddlerhood and early childhood period. In a sample of 167 toddlers (78.4% White, 18.9% bi-/multiracial; 45% female) in the Oregon Infant Development Study, higher mother-reported externalizing behaviors at child age 24 months significantly predicted larger mother-reported (subjective) ratings of body size/shape at age 10, after controlling for child gender, child’s BMI at 24 months, family income, and parents’ psychopathology (Holm-Denoma, Smith, Lewinsohn, & Pettit, 2014). Follow-up assessment of specific types of externalizing behaviors indicated that higher mother-reported ratings of aggressive behavior and anger at 24 months significantly predicted higher child BMI percentile at age 10. Among a nationally-representative sample of 755 children and their mothers in the US, a significant relationship between clinically meaningful behavior problems (in the 90th percentile of the cohort on the Behavior Problem Index) and child overweight was confounded by maternal obesity and maternal education, such that maternal obesity and lower education were associated with a stronger relationship between the child variables (Lumeng, Gannon, Cabral, Frank, & Zuckerman, 2003).

A few studies examining the effect of obesity on externalizing behavior provide support for the co-occurrence of overweight status and externalizing behaviors but the longitudinal associations are inconsistent and may differ by child sex. For example, in a nationally-representative sample of 9949 kindergarten and first-grade children (63.7% White; 50% female), there was a significant association at baseline between overweight status and teacher-reported externalizing behavior problems in girls, but not boys (Datar, Sturm, & Magnabosco, 2004). However, overweight status was not a risk factor for the onset of new behavior problems two years later for either sex. Among 11,202 children in the Millennium Cohort Study (89.5% White; UK; 50% female), obesity status of 3-year-old boys was not associated with significantly more conduct problems than their normal-weight peers at age 5 after controlling for conduct problems at baseline and overweight status at age 5 (Griffiths, Dezateux, & Hill, 2011). In another study of 8000 children (63% White, 10% African American, 16% Hispanic; 52% female; ECLS-K) in the US, assessed at four times points from kindergarten to the third grade, the moderating effect of sex was also found (Gable, Krull, & Chang, 2009). Teacher-reported behavior problems increased over time among boys who were either never overweight or found to be overweight in the third grade only. The externalizing behaviors of boys who were persistently overweight from kindergarten to third grade did not change over time. In comparison, girls who were either persistently overweight or overweight in the third grade only had significantly more teacher-reported behavior problems than peers who were never overweight during this period. Additionally, externalizing behavior increased over time for girls who were overweight in the third grade only.

Additional research suggests that this relationship is also found in later developmental periods but appears to be more salient to early childhood. In a nationally-representative sample of 629 normal-weight children (53% White, 27% Black, 20% Hispanic; 47% female) from the 1998 NLSY, mother-reported behavior problems at age 8 were associated with overweight BMI status two years later (Lumeng et al., 2003). Among 655 adolescents in a prospective cohort study (New York, US; Children in the Community Study), those with disruptive behavior disorders (e.g., attention deficit hyperactivity disorder, oppositional defiant disorder, conduct disorder) at 9–16 years of age had higher concurrent BMI scores than their peers at ages 11–20, 16–26, and 27–38 (Anderson, Cohen, Naumova, & Must, 2006). However, disruptive behavior disorders were not associated with annual change in BMI over time, suggesting that both the presence of a disruptive behavior disorder and elevated weight status begin earlier in childhood and persist until adolescence and adulthood. A 20-year longitudinal cohort study that began as a randomized trial of a universal preventive intervention for behavior problems in the first grade provides further support for this relationship, demonstrating that behavioral symptoms (i.e., attention deficit hyperactivity disorder & conduct disorder) in 655 adolescents at age 10 (85% White; 51% female) predicted overweight status at age 14, which persisted into early adulthood (McClure, Eddy, Kjellstrand, Snodgrass, & Martinez, 2012).

2.6 Adverse events.Our literature search yielded two studies on the relation between adverse events (e.g., trauma, neglect, abuse) in childhood and weight status later in life. A study of 20- to 27-year-old women who were sexually abused in childhood (*n* = 84; *m[at abuse]* = 7.8 years) gained body mass at a higher rate from childhood through adulthood and were significantly more likely to become obese compared to a control group with no abuse history (Noll, Zeller, Trickett, & Putnam, 2007). A study from Add Health (*n* = 8471; *m* = 15.5 years; 59% White; 53% female; pooled from 1995–2008) included retrospective measurement of physical abuse, sexual abuse, and neglect as indicators of child maltreatment before sixth grade, which was positively associated with greater rates of growth in BMI into adolescence (Shin & Miller, 2012). Further, neglect and physical abuse, when examined independently, were associated with baseline BMI but not the BMI growth rate. Although not identified in our formal search, a second study from Add Health (*n* = 15,197) using the same retrospective data found that a history of child sexual abuse that occurred prior to the 6th grade increased the risk for overweight and obesity at age 22 years among boys in the sample, but not for girls (Fuemmeler et al., 2009). Among women with a history of physical abuse, higher rates of skipping meals to lose weight and problematic eating were found. These studies are consistent with the findings of a meta-analysis of 4 prospective and 19 retrospective cohort studies (*n* = 112,708; *m* = 19-57 years) reporting the association between adverse events during childhood on adult obesity (Hemmingsson, Johansson, & Reynisdottir, 2014). A significant effect of childhood adverse life events on likelihood of being obese in adulthood was found. Further, there was no differential effect on this finding when general, physical, emotional, or sexual abuse were examined independently but severe abuse was significantly more associated with risk for obesity compared to light/moderate abuse.

## 3. Factors in the School Age Children Stage

3.1 Nutrition and dietary intake.A number of studies with varied designs and research questions have attempted to shed light on the nuanced relationship between childhood dietary intake and weight. A recent meta-analysis found moderately strong evidence from methodologically rigorous longitudinal cohort studies in children and adolescents to suggest that there is a positive association between dietary energy density and increased adiposity (Perez-Escamilla et al., 2012). In a yearlong longitudinal study of 10,769 children (*m* = 9-14 years; 57% female) found that a rise in caloric intake during the study period was associated with an increase in BMI (Berkey et al., 2000). Additionally, girls who reported a higher caloric intake also had larger increases in BMI (Berkey et al., 2000). This relationship did not hold for boys. A study using a sample of 216 economically disadvantaged children (*m* = 9 years; 56% female) found no relationship between dietary quality and change in BMI in the full sample, although improvements in dietary quality for children who were overweight at baseline were associated with lower BMIs at follow-up (Lioret et al., 2014).

A number of longitudinal studies have examined overall dietary intake in relation to child BMI change and have found no evidence for the relationship. One study of 384 Danish children (*m* = 10 years; 55% female) examined fat intake and subsequent weight change nine years later and found no relation (Brixval, Andersen, & Heitmann, 2009). Another study looked at cross-sectional and longitudinal associations between energy intake and BMI in a sample of 1349 children (*m* = 11 years; 54% female) and found no significant associations (Borradaile et al., 2008). Similar findings emerged from an 18-month study of 268 children in rural communities in the Western US (*m* = 10 years; 46% female) (Laurson, Eisenmann, & Moore, 2008) as well as a 10-year longitudinal study of 196 non-obese girls (*m* = 10 years) from the Cambridge, MA area (Phillips et al., 2004).

Another technique that has been used to explain the relationship between dietary intake, nutrition, and obesity in children is to describe clusters of health behaviors and observed relations to health outcomes. One study of 556 German children/adolescents (*m* = 11–17 years) identified four clusters of health-related behaviors (e.g., activity levels, dietary habits), noting that the prevalence of obesity increased in all four clusters at the 6-year follow-up (Spengler, Mess, Schmocker, & Woll, 2014). However, the cluster that included children/adolescents with low diet quality, low activity, and high media use had the highest increase in overweight during the study (Spengler et al., 2014). Other studies have sought to model the impact of changes in specific macronutrients and subsequent overweight/obesity. Emerging research from the transitional society of China can add important context to this research due to the unique opportunity to observe population-level trends in dietary intake and subsequent health outcomes. For example, a recent study with a group of 95 children (*m* = 6–13 years) found that higher meat and carbohydrate intake was related to later increases in adiposity (Wang, Ge, & Popkin, 2003).

Specific foods, food groups, and nutrients have also been investigated for their links to weight in childhood. We identified four longitudinal studies demonstrating a link between sugar-sweetened beverage consumption and percent body fat and/or BMI. One 10-year longitudinal study of 132 girls (*m* = 10 years) examined the impact of several energy-dense snack foods (e.g., ice cream, chips, soda) finding that soda was the only one related to BMI over time (Phillips et al., 2004). Other longitudinal studies demonstrated broader impacts of energy dense foods. In a study of 14,355 children (*m* = 9-14 years; 54% female) increased consumption of fried foods away from the home was associated with increased BMI, as was greater intake of other unhealthy foods including sugar-sweetened beverages and trans fats (Taveras et al., 2005). Another study of 1373 Australian children (*m* = 8 years; 50% female) found that the frequency of eating take-out foods was positively related to BMI (Hesketh et al., 2009).

A few studies have looked at meal timing and frequency in relation to child weight outcomes. One study of 807 Flemish children (*m* = 10 years; 48% female) found that higher frequency of breakfast consumption across five years was associated with smaller increases in BMI (Haerens, Vereecken, Maes, & De Bourdeaudhuij, 2010).Examining both meal timing and frequency, one study of 101 girls (*m* = 8-12 years) found that eating between 4.0 and 5.9 times per day, and limiting evening and night eating, was associated with smaller increases in BMI (O. M. Thompson et al., 2006).

3.2 Physical activity and sedentary behavior.Collectively, research indicates that children are not meeting physical activity guidelines (Coppinger, Jeanes, Dabinett, Voegele, & Reeves, 2010) and spend a great deal of time in sedentary behaviors, including high media use for example (Rideout, Foehr, & Roberts, 2016). A number of longitudinal studies have shown that BMI and other measures of adiposity are negatively associated with physical activity over time (Ara et al., 2006; Berkey et al., 2000; Carlson, Crespo, Sallis, Patterson, & Elder, 2012; Dunton et al., 2012; Fulton et al., 2009; Haerens et al., 2010; McGavock, Torrance, McGuire, Wozny, & Lewanczuk, 2009; Richmond et al., 2014) and positively associated with sedentary behavior (Falbe et al., 2013; Fuller-Tyszkiewicz et al., 2012). A year-long longitudinal study of 10,769 children (*m* = 9-14 years) found that girls who were less physically active had larger increases in BMI, though this relationship was not significant for boys (Berkey et al., 2000). A sample of 1670 Flemish children (*m* = 10.0 years, SD = 0.4; 48% female) followed for four years showed a significant negative relationship between self-reported sports participation and BMI z-score, and a positive relationship between decreased self-reported hours spent in physical education at school over time and increases in BMI z-score (Haerens et al., 2010). One study of 902 Canadian youth (*m* = 8-16 years; 54% female) found that both low cardiorespiratory fitness and decreases in fitness over time were significantly associated with weight gain over a two-year period (McGavock et al., 2009).

Particular clusters of physical activity/sedentary behaviors have also been found to be relevant for obesity risk. For example, an analysis of clustered behaviors over a six-year study with 1642 German youth (*m* = 11-17 years) found that a pattern of low activity levels, high media use, and low dietary quality had the highest increase in prevalence of overweight, while children with the pattern of high physical activity levels average media use and dietary quality had the smallest (and non-significant) increase in prevalence of overweight (Spengler et al., 2014).

Contrary to the research described above, some studies have not found a significant relationship between physical activity or sedentary behaviors and BMI, or other weight/adiposity indicators (Borradaile et al., 2008; Fulton et al., 2009; Laurson et al., 2008; Must et al., 2007). A large, racially diverse sample of 1349 children (*m* = 11.2 years, SD = 1.0; 46% African American; 22.2% Asian, 15.5 Hispanic, 12.3% White; 54.1% female) from low socioeconomic schools did not show any relationship between self-reported physical activity and sedentary behavior and BMI change over time (Borradaile et al., 2008). A study of a 173 girls (*m* = 10.0 years; 75% White, 14% Black; Cambridge, MA) found that self-reported physical activity and physical inactivity were unrelated to changes in BMI z-score (Must et al., 2007). However, after controlling for parental overweight, self-reported physical activity was inversely related and inactivity was positively related to increased body fat (Must et al., 2007).

3.3 Sleep.A recent meta-analysis of cross-sectional and longitudinal study designs concluded that short sleep duration doubles the risk of overweight and obesity in childhood and adolescence (Fatima & Mamun, 2015). In a prospective cohort study of White and Hispanic children recruited between ages 6–12 years (*m* = 8.9 years; 63.2% White, 36.8% Hispanic; 49% female), sleeping less than 7.5 hours per night increased the risk of obesity at 5-year follow-up compared to sleeping 9 hours or more per night, and having sleep disordered breathing was also found to predict higher BMI at follow-up (Silva et al., 2011). In a Canadian birth cohort study of 1106 children (53% female), the sleep trajectory (i.e., “short persistent/increasing,” “10-hour persistent,” and “11-hour persistent”) from ages 2.5 to 6 years had an inverse association with being overweight/obese at ages 6 and 7 for boys only, and this was mediated by eating at irregular hours and eating too much or too fast (Tatone-Tokuda et al., 2012). Similarly, a birth cohort study (*n* = 244; 44% female) from New Zealand found that for each additional hour of sleep from age 3 to 5 years there was a reduction in risk of being overweight at age 7 (Carter, Taylor, Williams, & Taylor, 2011).

The same relationship seems not to exist in adolescence, as the longitudinal studies captured by our search did not report a significant relation between sleep duration and obesity. A study using data from the first two waves of Add Health (*n* = 13,568; *m* = 15.96 years, SD = 0.11) found that shortened sleep duration (i.e., sleeping less than 6 hours) was not predictive of obesity at 1-year follow-up (Calamaro et al., 2010). Change in sleep over a two-year period was not related to change in BMI or percent body fat in a study of 723 predominantly White adolescents (*m[baseline]* = 14.7 years, SD = 1.84) (Lytle et al., 2013). This supports focusing on the effects of sleep during childhood.

3.4 Self-esteem. Although there is substantial evidence demonstrating that being overweight/obese may lead to lower self-esteem and body satisfaction (e.g., Angle et al., 2005; Clark & Tiggemann, 2008; Frisen, Lunde, & Berg, 2015), a few studies have found that self-esteem and body image may predict changes in weight and self-esteem over time. The school age stage may be particularly salient. A recent review of the literature found five studies that examined how self-esteem in mid- or late-childhood impacted obesity during adolescence (Incledon, Gerner, Hay, Brennan, & Wake, 2013). The review found that there is some evidence for global self-esteem predicting incidence of obesity, albeit some studies did not find this relation. There were inconsistent findings for the relation between physical self-esteem and obesity and the authors conclude that this may be explained by methodological differences between studies. Data on 7588 people (51.1% female) from a 1970 British Cohort study indicated that self-esteem at age 10 predicted weight gain in men and women at age 30 (Ternouth, Collier, & Maughan, 2009). Improvement in self- and parent-reported child global self-esteem was found to predict a decline in BMI over four years in an Australian sample of 189 overweight/ mildly obese 5- to 9-year-old children (61% female; 53% in intervention group) recruited in primary care and followed over four years (*m[follow-up]* = 7.4 years, SD = 1.4) (Incledon et al., 2013). A study of 77 Swedish children (53% female, *m[baseline]* = 12.7 years) found a difference in BMI between children who had high and low self-reported physical self-worth at mean age 12.7 and 17.7 years for boys and girls and at mean age 17.7 the same difference was found for body fat (Raustorp, Archer, Svensson, Perlinger, & Alricsson, 2009). Additionally, in girls, physical self-esteem was negatively predicted by BMI at mean age 12.7 and at mean age 17.7 it was negatively predicted by body fat.

3.5 Maternal mental health. In our search, parental mental health was most commonly characterized by mother’s level of depression, which can inhibit effective family management practices thereby negatively impacting children’s health. The majority of studies occurred with samples of school age children with a few exceptions with slightly younger or older children. The literature is inconsistent regarding the effect of maternal mental health on child weight. In a study of elementary school children from the Early Childhood Longitudinal Study (ECLS-K) (*n* = 21,260; *m[kindergarten]* = 74.45 months, SE = 0.13), maternal depression measured during kindergarten and third grade was differentially associated with child BMI over time by child gender. For girls, greater maternal depression in kindergarten was related to a decrease in the child’s BMI from kindergarten to third grade but an overall increase in BMI from kindergarten to fifth grade, suggesting a binomial curve. For boys, maternal depression in kindergarten, but not third grade, was associated with higher BMI in fifth grade (Duarte, Shen, Wu, & Must, 2012). In the Oregon Adolescent Depression Project, a small sample study of psychosocial predictors of BMI in late childhood (*n* = 38; *m* = 10.0 years, SD = 0.84; 45% female), results revealed that children of mothers with an Axis I disorder had higher BMI 8 years later (Holm-Denoma et al., 2014).

In a study focused on problem behavior and overweight using data from 8- to 11-year-old children in the 1998 National Longitudinal Survey of Youth (NLSY), a multigenerational study of 755 children (50% female), interactions between maternal depression and race, maternal obesity, academic grade retention, maternal education, family poverty status, significant behavior problems and a cognitive stimulation score from the Home Observation for Measurement of the Environment-Short Form were all found to be statistically insignificant in the relationship between behavior problems and overweight (Lumeng et al., 2003). In the Early Prediction of Adolescent Depression study conducted in the United Kingdom (UK), adolescents (*n* = 289; *m* = 12.4 years; 52% female) and their parents were independently screened for depressive symptoms (measured by the Child and Adolescent Psychiatric Assessment) and compared to two groups from the earlier Avon Longitudinal Study of Parents and Children (ALSPC). There were no significant longitudinal associations between BMI and new depressive symptoms in adolescents at high risk for depression—defined by their parents’ recurrent depression (Hammerton, Thapar, & Thapar, 2014).

Socioeconomic status affects the relation between maternal depression and child weight. In one study, maternal depression mediated the relationship between family income and BMI patterns (income did not have a direct effect on BMI) using data from the National Institute of Child Health and Human Development Study of Early Child Care and Youth Development (*n* = 1090; assessed 7 times between 24 months old and sixth grade; conditionally randomly sampled to obtain a diverse study sample of 24% racial/ethnic minority; 11% mothers with less than a high school education; 14% single mothers) (Lane et al., 2013). A study in Ireland measured health-related quality of life in overweight children (*n* = 255; *m* = 7-12 years; 50% female) and concluded that parental mental health is more prevalent in highly populated urban areas with higher poverty rates, which is associated with fewer healthy resources and experiences for the children (Wynne et al., 2014).

**4. Factors in the Adolescents–Teenagers Stage**

**4.1 Nutrition and dietary intake.** In Project Eat, a longitudinal study of 2516 Minnesota adolescents (*m*[younger group]= 13 years, *m*[older group] = 17 years; 55% female; 32% of sample in younger group), gender differences were identified. Among females, higher servings of sugar-sweetened beverages and diet soda were positively associated with overweight while more servings of fruits and vegetables, breakfast consumption, lower total caloric intake, less fast food consumption, and less availability of high-caloric snack foods in the home were negatively associated with overweight and lower fast food consumption was a protective factor for persistence of overweight (but not associated with incidence of overweight) (Haines, Neumark-Sztainer, Wall, & Story, 2007). Among males, eating fewer servings of snacks per day and breakfast consumption were negatively associated with overweight at time 2. In a study that examined the findings among women in greater detail, consumption of beverages was not associated with weight gain, except that consumption of low-calorie soft drinks was positively associated with weight gain and white milk consumption was negatively related (Vanselow, Pereira, Neumark-Sztainer, & Raatz, 2009). However, the authors noted that these associations did not appear to be a monotonic linear dose-response relation. Further, the positive association with low-calorie soft drinks was no longer present after adjusting for dieting and parental weight-related concerns, which suggests that the use of low-calorie soft drinks is a marker for more general dietary behaviors and weight concerns. A third study from Project EAT found an inverse dose-response relationship between frequency of breakfast consumption and BMI at the 5-year follow-up assessment, adjusting for baseline breakfast frequency and BMI (Timlin, Pereira, Story, & Neumark-Sztainer, 2008).

Participants in two longitudinal cohort studies, the Identifying Determinants of Eating and Activity (IDEA) study and the Etiology of Childhood Obesity (ECHO) study (n = 693; *m*=15 years; 51% female) reported that there was no longitudinal relation between diet soda consumption and BMI and percent body fat or breakfast intake on BMI and percent body fat (in females), which had been identified in cross-sectional analyses from the first wave of the study’s data (Laska, Murray, Lytle, & Harnack, 2012). In the Oslo Youth Study (*n* = 422; *m* = 15 years; 51% female) no differences were found in BMI over an 8-year period by long-term sugar-sweetened carbonated beverage consumption (Kvaavik, Andersen, & Klepp, 2005). Analysis of DONALD (*n* = 244; *m* = 12 years; 49% female) found that boys’ energetic beverage (a composite variable of regular soft drinks and fruit juices) consumption was not associated with BMI or body fat percentage after five years, but for girls, increases in energetic beverage consumption was associated with increased BMI even though baseline consumption did not predict BMI or body fat percentage at follow-up (Libuda et al., 2008). Time-varying BMI was unrelated to eating behaviors (e.g., fruit and vegetable intake, services whole grains, sugar-sweetened soda) tracked over time with the exception of an inverse association with time-varying snacks (*n* = 2785; *m* = 16 years; US; 55% female; NEXT Generation Health Study) (Lipsky et al., 2015).

Using data from Add Health (*n* = 7788; *m* = 15 years; 52% female) breakfast consumption in both adolescence and young adulthood was protective against chronic obesity, defined as persistence in obesity across the two study time points (Merten, Williams, & Shriver, 2009). A second Add Health study (*n* = 9919; *m* = 16 years) found that more days of fast food consumption, assessed at wave 2 (between ages 11 and 21 years), predicted increased zBMI assessed at wave 4 (ages 18 to 27 years), and fewer days of breakfast consumption at wave 2, along with decreases in breakfast consumption between waves 2 and 3, predicted increased zBMI at wave 3 (Niemeier, Raynor, Lloyd-Richardson, Rogers, & Wing, 2006). A cohort study of 8726 Australian females (*m* = 18–23 years) found that women who maintained their weight at the 4-year follow-up consumed less takeout food than women who gained weight (Ball, Brown, & Crawford, 2002).

Data from the Amsterdam Growth and Health Longitudinal Study (AGHLS) provides a number of relevant studies. First, evidence from 186 adolescents (*m* = 14 years; 49% female) indicated that greater protein intake (but not fat or carbohydrates) related to higher fat mass and, unexpectedly, fat mass was negatively related to the daily intake of energy per kg body mass (Kemper, Post, Twisk, & van Mechelen, 1999). Second, another study (*n* = 350; *m[baseline]* = 13 years; 52% female) found no longitudinal associations between percent energy intake from protein, fat, carbohydrates, or alcohol and body fat at age 36 (Koppes, Boon, Nooyens, van Mechelen, & Saris, 2009). However, the authors pointed out potential issues with the tracking of macronutrients and the potential of underreporting total intake. Third, no relationship was found between sugar-sweetened beverages (excluding 100% fruit juices) at age 13 and BMI at follow-up (24–30 years later) for males or females (*n* = 238; *m* = 13 years; 52% female) (Stoof, Twisk, & Olthof, 2013). For the males in this sample, each additional serving of sugar-sweetened beverages (excluding 100% fruit juices) at 13 years was associated with 1.14% higher percentage of total fat and 1.63% higher percentage of trunk fat in adulthood after accounting for confounders. Fourth, in a subsample of 13-year-olds (*n* = 168; 57% female) fruit intake was not associated with BMI at follow-up 24-30 years later but low fruit intake (being in lowest quartile of intake) was significantly associated with lower sum of skin folds (te Velde, Twisk, & Brug, 2007). However, women in the lowest quartiles of vegetable intake had signiﬁcantly higher BMI and sum of skinfolds as well as greater positive changes in these parameters compared to those women in the higher quartiles. Fifth, another study examining long-term outcomes 24 to 30 years after study entry (*n* = 374; *m* = 13 years; 57% female) no evidence was found for the hypothesis that dairy intake protects against overweight and metabolic syndrome in adulthood but the authors did report that “high-fat dairy intake during adolescence tended to be higher in subjects with lower weight, lower percent body fat, lower waist circumference, and lower triglyceride concentrations at 36 years” (te Velde et al., 2011). Last, body fat, as measured by subscapular skinfold thickness and waist circumference, was positively associated with alcohol intake among males, negatively associated with energy intake among females, and positively associated with carbohydrate intake among females 24 to 30 years after study entry (*n* = 182; *m* = 13 years; 54% female (van Lenthe, van Mechelen, Kemper, & Post, 1998).[[1]](#footnote-1)

4.2 Physical activity and sedentary behavior.Numerous cross-sectional and longitudinal studies have demonstrated physical activity decreases significantly for males and females during adolescence as more time is spent in sedentary activities (Gortmaker et al., 2012; Troiano et al., 2008). Overall, the studies identified in our search found evidence supporting a positive relationship between high levels of sedentary time and higher BMI (Ball et al., 2002; Calamaro et al., 2010; Elgar, Roberts, Moore, & Tudor-Smith, 2005; Haines et al., 2007). For example, in a sample of 355 Welsh adolescents (*m* = 12 years; 55% female), higher self-reported sedentary time at baseline predicted higher BMI at follow-up four years later (Elgar et al., 2005). Similarly, a sample of 13,568 participants from the National Longitudinal Study of Adolescent to Adult Health (NLSAAH) (*m* = 16 years; 50% female) found that adolescents who self-reported two or more hours of daily television viewing time were at higher risk of obesity at follow-up one to two years later (Calamaro et al., 2010). A cohort study of 8726 Australian females (*m* = 18-23 years) found that individuals who reported less sitting time at baseline were also more likely to maintain their baseline body weight four years later (Ball et al., 2002). Lastly, an analysis of participants in Project EAT, a longitudinal study of 2516 Minnesota adolescents (*m[younger group]* = 13 years, *m[older group]* = 17 years; 55% female; 32% of sample in younger group), found that for females only, baseline hours of sedentary behavior was associated with later overweight (Haines et al., 2007).

Support for the relationship between amount of physical activity and weight gain over time showed was mixed in our sample of studies. Three studies reported that higher physical activity levels protected against later weight gain (Bild et al., 1996; Elgar et al., 2005; Reinehr, Brylak, Alexy, Kersting, & Andler, 2003). For example, data from 75 children and adolescents in an intensive obesity treatment program in Germany (*m* = 12 years; 48% female) showed that the only individuals who were successful at reducing their BMI by the end of the one-year program were those who had participated in exercise groups before the treatment began (Reinehr et al., 2003). Second, a large study of 4279 adolescents and young adults (*m* = 18–30 years; 51% female) examined factors that predicted weight loss or gain two years later, using objectively measured fitness through treadmill tests (Bild et al., 1996). The study found that lower baseline physical fitness predicted weight loss, while higher physical fitness at baseline was associated with weight gain. Further, among overweight individuals, low baseline fitness and increased physical activity were associated with weight loss over the two-year study.

Evidence also suggests that the impact of physical activity on later weight status may vary by gender. One study identified clusters of adolescent activity and dietary patterns using data from 9241 participants in NLSAAH (*m* = 11–21 years) (Boone-Heinonen et al., 2008). Findings showed that by comparison of clusters characterized by participation in school clubs and sports, the adjusted odds of prevalent and incident obesity were higher for females in all other clusters, but this was not true for males.

The relationship between physical activity and later weight outcomes is further complicated by other mixed findings. Evidence from a study of 186 adolescents (*m* = 14 years; 49% female; AGHLS) found that there was a significant inverse relationship between skinfold thickness and physical activity (Kemper et al., 1999). However, this relationship did not hold for BMI and physical activity. Additionally, some evidence was contrary to, or did not support, the hypothesis that low physical activity leads to weight gain. One study found that in a sample of 256 girls (*m* = 14 years), changes in moderate- to vigorous-physical activity at follow up between two to four years later were not associated with BMI (Rodgers et al., 2013). Although, increases specifically in vigorous physical activity, assessed using accelerometers, were associated with reduced body fat. Further, three studies found no relationship between physical activity and weight outcomes (Ball et al., 2002; Calamaro et al., 2010; Haines et al., 2007), and one study of 182 adolescents in AGHLS (*m* = 14 years; 54% female) found counterintuitive evidence that males had a small positive association between physical activity and subscapular skinfold thickness (van Lenthe et al., 1998).

4.3 Depressed mood.There are complex and potentially reciprocal relationships between measured body weight, perceived body weight, and depressive symptoms for adolescents and young adults. A number of studies have shown a positive relationship between depressive symptoms and overweight/obesity, both cross-sectionally and over time (Korczak, Lipman, Morrison, & Szatmari, 2013); however, reviews of this literature have revealed mixed conclusions (Incledon, Wake, & Hay, 2011).

Two studies using data from Add Health found that greater depressive symptoms predicted higher BMI at later time points. One analysis of a subsample of 13,568 adolescents (*m* = 16 years; 50% female) showed that individuals with major depression, assessed using the Center for Epidemiologic Studies Depression Scale Revised (Radloff, 1977), were twice as likely to be obese at follow-up compared to their peers without depression (Calamaro et al., 2010). Interestingly, there was no cross-sectional relationship found between depression and obesity in this sample. A second analysis of a subsample of 9374 adolescents (grades 7-12, 49% female) found that depressed mood at baseline independently predicted obesity at the 1-year follow-up, after controlling for baseline BMI and other potential confounders (Goodman & Whitaker, 2002). Additionally, analyses did not support a reciprocal relationship. That is, obesity at baseline did not predict depressive symptoms at follow-up.

Three studies in our sample found gender differences in this relationship. A study using data from Project EAT, a longitudinal study of 2516 Minnesota adolescents (*m[younger group]* = 13 years, *m[older group]* = 17 years; 55% female; 32% of sample in younger group), did not find a relationship between depressive symptoms and later weight status among females whereas depressive symptoms at baseline predicted overweight three years later among males (Haines et al., 2007). However, this relationship was not significant when the researchers restricted the analysis to incident cases of overweight, meaning that body weight appears to continue to increase with depressive symptoms in males who are already overweight at baseline. A study of 285 mostly White adolescents in Pittsburgh (*m* = 12 years; 49% female) found that depressed adolescents began the study with a higher average BMI and depressed adolescents also had a consistently higher BMI over time (Rofey et al., 2009). However, when examining differences by gender, the study found that the impact of depression on overweight was only significant for females. Additionally, an analysis of data from the 2074 adolescents in the 1994-1998 NLSYs (*m* = 17 years; 49% female) found that the only group in the analysis with a significant relationship between depressive symptoms and weight was African American girls (Kowaleski-Jones & Christie-Mizell, 2010). The findings indicated that symptoms of depression were positively related to BMI.

This relationship has also been examined using latent class modeling of trajectories of weight over time and changes in associated processes, such as depressive symptoms. The study of 1258 adolescents in the Cincinnati, OH area (*m* = 14 years; 51% female) found that while there was no significant predictive power of change in BMI over time, higher BMI did predict depression overall. A longitudinal school-based cohort study that simultaneously examined weight and mental health trajectories found that 5.6% of adolescents (*m[baseline]* = 14.4 years; 52.9% White, 47.1% Black; 51.2% female) were in a class characterized by “overweight, becoming obese, with declining mental health” (Kubzansky, Gilthorpe, & Goodman, 2012).

Researchers have also investigated the role of peer influences on depressed mood in adolescents. Three studies in our search explored this relationship. One study using the full sample from Project EAT found that weight-related teasing at baseline predicted overweight status at follow-up (Haines et al., 2007). Using data from 1694 Australian adolescents (*m* = 14 years; 50% female), females and males who reporting being bullied occasionally/often at age 14 were at higher odds of being obese at age 21 compared with peers who were never bullied (Mamun, O'Callaghan, Williams, & Najman, 2013). Last, an investigation of 1287 Canadian adolescents (*m[baseline]* = 12–13 years), found differences in the role of peer victimization based on weight status and gender (Adams & Bukowski, 2008). Among females who were obese, victimization was linked to lower self-concept, depressive symptoms, and higher BMI four years later. Among obese males, victimization was related to lower self-concept and decreases in BMI four years later. There was no relationship found between victimization, depression, and BMI for non-obese adolescents.

4.4 Perceptions of weight and body image.There is some empirical evidence to support that the way youth perceive their weight and bodies in adolescence may lead to obesity. Using a diverse sub-sample from NLSAAH (*n* = 13, 568; *m[baseline]* = 15.8 years, SD = 1.6; 12.3% Hispanic, 65.4% Non-Hispanic Black, 15.6% Non-Hispanic Asian; 49.8% female), researchers found that body size overestimation increased the risk of overweight onset one year later compared to accurate perception. Conversely, body size underestimation decreased the risk of overweight and obesity onset (Liechty & Lee, 2015). In another sub-sample of the same study (*n* = 6523; *m[baseline]* = 16.15 years, SD = 1.59; 19.4% Black, 15.0% Hispanic; 58.4% female) adolescents were followed for 12 years (*m* = 28.74 years at follow-up, SD = 1.59). The study found that adolescents who misperceived themselves as being overweight were at greater risk of becoming obese in adulthood than those who perceived their weight accurately and this was significantly stronger for males (Sutin & Terracciano, 2015). Additionally, a study of middle school (*n* = 805; *m[T1]* = 12 years, SD = 0.8; *m[T2]* = 17.2 years, SD = 0.6) and high school (*n* = 1711; *m[T1]* = 15.8 years, SD = 0.8; *m[T2]* = 20.4 years, SD = 0.8) students (55.1% female) found that body dissatisfaction and weight concerns at baseline predicted overweight five years later for both males and females (Haines et al., 2007).In theNHLBI Growth and Health Study, girl’s (*n* = 2150; age 9–19 years; 49% Black, 51% White) with greater body dissatisfaction was related to greater growth in BMI [435].

4.5 Corollary health behaviors.A number of corollary health behaviors have a relationship with weight status during the adolescence to young adulthood period. Cigarette smoking was the most prevalent in our literature search, which typically has a negative relationship with BMI. One study examined a sample of 2665 adolescents in the Health and Behaviour in Teenagers study (*m[baseline]* = 11-12 years; 63.1% White, 23.0% Black, 11.2% Asian; London, England; 42.1% female) who had never smoked before grade 11 (Fidler, West, Van Jaarsveld, Jarvis, & Wardle, 2007). Regular smokers had a lower BMI than other students, controlling for ethnicity, SES, status of puberty, diet and exercise, and baseline BMI. Furthermore, cigarette smoking was negatively correlated with adiposity during adolescence but not during adulthood in the longitudinal AGHLS (*n* = 181; *m[baseline]* = 13.1 years, SD = 0.8; *m[follow-up]* = 29.1 years, SD = 0.9; 54% female) (Twisk, VanMechelen, Kemper, & Post, 1997). Among boys only, cigarette smoking was associated with lower BMI and shorter height in the Natural History of Nicotine Dependence in Teens Study in Canada (*n* = 929; grade 7 at baseline; 51.5% female) (O'loughlin, Karp, Henderson, & Gray-Donald, 2008). Conversely, some evidence suggests that obesity in adolescence increases risk for tobacco use. In a study of adolescent girls from Add Health (*n* = 4102; *m[obese]* = 14.98 years, SD = 0.8; *m[non-obese]* = 15.07 years, SD = 0.3; 57% White, 18% Black, 16% Hispanic, 7% Asian, 2% American Indian; ), being obese increased the risk of nicotine addiction six years later, after controlling for baseline smoking, demographics, and family smoking compared to non-obese adolescent girls (Hussaini, Nicholson, Shera, Stettler, & Kinsman, 2011).

Two studies in our review found that smoking contributed to overweight or obesity. A study of 5156 children from the 1979 NLSY (*m[baseline]* = 14 years; 41.7% White, 34.9% Black, 21.6% Hispanic; 50% female), smoking cigarettes was associated with chronic obesity through adolescence, but the same was not found for alcohol or marijuana use (Huang, Lanza, Wright-Volel, & Anglin, 2013). In a sample of southeastern American Indian adolescents drawn from the Teen Pathways Study (*n* = 134; *m[baseline]* = 13.6 years, SD = 1.5; 90% Lumbee American Indian; 57% female), earlier initiation of cigarette smoking and more frequent smoking was associated with higher BMI and smoking was found to be ineffective as a self-reported weight control method (Newman, Sontag, & Salvato, 2006). Some studies, however, have not found a relationship between smoking and BMI. The Quebec Heart Health Demonstration Project in Canada (*n* = 1188; grade 4 at baseline; 47.2% female) did not find that smoking contributed any significant changes to their model of the relationship between diet and BMI from grade 4 to 9 (Bisset, Gauvin, Potvin, & Paradis, 2007). Results from the Oslo Youth Study in Norway (*n* = 422; *m[baseline]* = 13 years; 50.1% female) indicated that men age 25 to 33 who were long-time, high consumers of soft drinks from adolescence to young adulthood were more likely to smoke cigarettes (Kvaavik et al., 2005). This was found for women and BMI was not correlated with soft drink intake.

Researchers have also examined the relationship between alcohol use in adolescence and BMI. In Australia, 219 parents and children (53% female) were assessed every three years from child age 9–18 years (Burke, Beilin, & Dunbar, 2001). For boys, alcohol intake was related to their BMI, and for girls, fathers’ alcohol consumption was associated with their BMI. Of the variables tested in this study (i.e., SES, BMI, diet, alcohol consumption, smoking, and physical fitness), the relationship between alcohol use in adolescence and BMI at age 18 was second only to that of physical activity. The role of self-esteem in the link between BMI and alcohol use was evident in a study from the 1992 and 1994 NLSYs (*n* = 1090; *m[baseline]* = 9-10 years; 42% White, 36% Black, 22% Hispanic; 51% female), which found that among children with a low BMI, decreasing self-esteem over the four-year study period was associated with a higher likelihood of consuming alcohol and smoking cigarettes, compared to children with a high BMI and constant or increasing self-esteem (Strauss, 2000). In the Northern Finland 1966 Birth Cohort Study (*n* = 5973; *m[baseline]* = 14 years; 50.1% female), men with high levels of alcohol consumption, low physical activity, and poor quality diets had increased risk for overweight in adulthood (Hakko et al., 2006). Among women in the study, high alcohol consumption, the presence of a chronic disease, low physical activity, and having at least three children were associated with increased risk for overweight in adulthood. In Project EAT (*n* = 2216; *m[baseline]* = 14.9 years, SD = 1.6; 63.1% White, 9.9% Black, 17.7% Asian, 3.8% Hispanic, 2.7% American Indian; 54.8% female), breakfast frequency at baseline was positively associated with carbohydrate and fiber intake, SES, White race, and physical activity at five year follow-up, and negatively associated with smoking, alcohol intake, BMI, and dieting to lose weight (Timlin et al., 2008). A longitudinal analysis from ages 13 to 27 years in AGHLS (*n* = 182; *m[baseline]* = 13 years; 53.8% female), alcohol consumption was associated with greater subscapular skinfold thickness among boys, but not girls (van Lenthe et al., 1998). Results from the Teens Eating for Energy and Nutrition at School study (*n* = 3010; *m[baseline]* =12.7 years; 72.1% White; Minnesota; 48.9% female) showed that at the beginning of 7th grade, depression was associated with BMI, but by the end of 8th grade, binge drinking, tobacco, other drug use, fighting, and depression were all associated with increased BMI over that one-year period (Pasch, Nelson, Lytle, Moe, & Perry, 2008).

Some evidence suggests that the use of substances, mainly alcohol, is related to BMI during the transition from adolescence to adulthood. In the Australian Longitudinal Study on Women’s Health (*n* = 8726; *m[baseline]* = 18–23 years), participants with a stable weight status during this transition were less likely to be obese and more likely to have healthy lifestyles (Ball et al., 2002). Smoking was associated with weight instability and lower alcohol consumption and better dietary practices were associated with weight status maintenance. However, when occupation, marital status, student status, and number of children were controlled for in the analyses, these associations were no longer present, which suggests that the association is small and potentially confounded by other variables. Data from a sample of 5563 twins (*m[baseline]* = 18.5 years; 51.8% female) in Finland, abstaining men and women who drank less than monthly during the transition from adolescence to young adulthood had a smaller increase in BMI than men and women who drank once to twice per month (Pajari, Pietilainen, Kaprio, Rose, & Saarni, 2010). Women who drank at least weekly had a larger waist circumference than women who drank once to twice per month, but this associated was not present when smoking, diet, and other variables were controlled for. Regular smoking was associated with weight loss for the entire sample of the Coronary Artery Risk Development in Young Adults study in the US (*n* = 4279; *m[baseline]* = 24.9 years; 20.1% Black men, 25.7% White men, 25.8% Black women, 25.6% White women) (Bild et al., 1996). The association was especially strong for overweight White women.

## 5. Parenting and Family Management

5.1 Parenting styles. In a systematic review, Sleddens et al. (2011) found that general parenting styles influence children’s diet, exercise behaviors, and weight. Parenting styles are commonly categorized based on the dimensions of warmth/responsiveness and demandingness/level of control (Maccoby & Martin, 1983). Four parenting styles are derived from the combinations of these dimensions: authoritative (warm and demanding), authoritarian (highly demanding but less warm), indulgent or permissive (high levels of warmth but less demanding), and neglectful or uninvolved (low on both warmth and demandingness). Sleddens et al. concluded that children raised with an authoritative parenting style have a healthier diet, are more physically active, and have lower BMI’s than those raised with the other styles. In a diverse sample of 4746 adolescents (*m[younger cohort, baseline]* = 12.8 years, SD = 0.8; *m[older cohort, baseline]* = 15.8 years, SD = 0.8), children of authoritative mothers had a lower BMI after five years whereas daughters with a permissive father had a higher fruit and vegetable intake (Berge, Wall, Loth, & Neumark-Sztainer, 2010). In the same sample, authoritative parenting was positively associated with having family meals five years after study enrollment for parent-adolescent dyads of the opposite sex (Berge, Wall, Neumark-Sztainer, Larson, & Story, 2010). In a study (National Institute of Child Health and Human Development Study of Early Child Care and Youth Development) of a diverse national sample of 1238 children (*m[baseline]* = 24 months; 49% female), higher income was related to greater likelihood of having a permissive mother, which in turn predicted an increased likelihood of being in the group with above average BMI between ages 2 and 11 years (Lane et al., 2013). Similarly, children of indulgent mothers had greater increases in weight three years after baseline (*m[male]* = 6.7 years, SD = 1.3; *m[female]* = 6.8, SD= 1.4).

In a sample of 465 Taiwanese parent-child dyads (*n[male]* = 231, *n[female]* = 234; *m[male, 1-year follow-up]* = 8.45 years, SD= 1.03; *m[female, 1-year follow-up]* = 8.35 years, SD= 1.02), parenting style moderated the relation between parental concerns[[2]](#footnote-2), feeding styles, and overweight (Tung & Yeh, 2014). Among more authoritative mothers, endorsing higher concern about child weight was associated with a greater likelihood that the child would be overweight one year later, but if the mother monitored more of her child’s diet, the child was less likely to be overweight one year later. Among more authoritarian mothers, monitoring increased the likelihood of the child being overweight and concern about child weight was not related to the child’s weight one year later. Concern about child weight increased the likelihood of the child being overweight among less authoritarian mothers and more permissive mothers.

5.2 Feeding practices. Feeding styles or practices—the strategies that parents use when feeding their children—have been found to prospectively predict eating behaviors (e.g., Rodenburg, Kremers, Oenema, & van de Mheen, 2014) and child weight (e.g., Anzman & Birch, 2009; Campbell et al., 2010; Jansen et al., 2014; Rodgers et al., 2013) across development. An Australian study of 323 mother-child dyads (*m[baseline]* = 2.03 years, SD= 0.37) found that maternal feeding behaviors predicted the child’s subsequent obesogenic eating behaviors. Specifically, higher maternal monitoring positively predicted child food approach behaviors one year later; emotional feeding (i.e., using food to calm) and encouragement positively predicted the child tendency to overeat; emotional feeding positively predicted child emotional eating; and higher levels of instrumental feeding (i.e., using food as reward) were correlated with increases in child BMI z-scores at follow-up (Rodgers et al., 2013). Flemish children (*n* = 727; *m* = 9.9 years, SD = 0.4; 51.9% female) who received soft drinks from their parents whenever they asked at age 10 (permissive parenting) consumed more soft drinks at age 16 (Verloigne, Van Lippevelde, Maes, Brug, & De Bourdeaudhuij, 2013).

A study of 1275 parent-child dyads (*m* = 8.2 years, SD = 0.5; 49.5% female) in the Netherlands examined how one-year changes in child snacking (fruit intake, energy-dense snacking, and sugar-sweetened beverage consumption) and BMI were related to five parental feeding styles: Instrumental Feeding (e.g., “I reward my child with something to eat when s/he is well behaved”), Emotional Feeding (e.g., “I give my child something to eat to make him/ her feel better when s/he has been hurt”), Encouragement (e.g., “I encourage my child to try foods s/he has not tasted before”), Overt Control (e.g., “I decide how many snacks my child should have”), and Covert Control (e.g., “I avoid buying unhealthy food in the supermarket”) (Rodenburg et al., 2014). Controlling for baseline child BMI and child and parental snacking, Instrumental Feeding predicted a small decrease in child fruit intake for which moderation analyses revealed that it was only significant when parents displayed a high level of Behavioral Control (e.g., “I try to know where my child goes after school”). Both Instrumental and Emotional feeding predicted a small increase in energy-dense snacking, while Encouragement predicted a decrease. Overt and Covert Control predicted small decreases in energy-dense snacking and sugar-sweetened beverage consumption. Covert Control and Instrumental Feeding predicted a minimal increase in child BMI. Moderation analyses revealed that the negative relation between Overt Control and sugar-sweetened beverage intake was only present for families where parents endorsed low levels of behavioral control; the negative relation between Covert Control and energy-dense snacking only existed for parents with low levels of psychological control (i.e., “I make my child feel guilty when he/she gets a low grade in school.”) and not for those with high levels of psychological control; and Emotional Feeding and energy-dense snacking was only significant for children of parents who used high levels of psychological control.

As described, the food that parents choose to make available in the home is another form of control. The home food environment or food availability has been studied as it relates to childhood obesity, albeit the number of longitudinal studies is limited and very few studies examined the impact of food availability on the child’s anthropometric measures. An Australian study of 161 5- to 6-year-old children and 132 10- to 12-year-old children examined the relation between family food environment (breakfast eating patterns, food consumption while watching television, parental provision of energy-dense foods, and child consumption of energy-dense food at home and away from home) and BMI and weight status at 3-year follow-up (Macfarlane, Cleland, Crawford, Campbell, & Timperio, 2009). No significant relation was found between provision of energy-dense foods and child weight. A cohort study in Vietnam of 526 children (*m* = 4-5 years; 51% female) found that better quality of the home food environment (i.e., presence of fruits, vegetables, eggs, meat, and milk) had a protective effect on changes in sum of skinfold thickness for both boys and girls at 1-year follow-up (Huynh et al., 2011).

Restrictive and pressuring feeding styles are two other types of parental control. The relation between restrictive feeding practices and weight is equivocal with studies finding an association with both weight gain (Thompson, Adair, & Bentley, 2013) and weight loss (Campbell et al., 2010). Restrictive feeding style has also been found to differentially affect BMI depending on child age. An Australian study of 204 5- to 6-year-olds and 188 10- to 12-year-olds (49.7% female) found that restrictive feeding style at baseline predicted lower BMI z-scores three years later in the 5- to 6-year olds but no relation was found for the 10- to 12-year-olds (Campbell et al., 2010). A study of 217 low-income, African American mother-infant dyads (*m* = 3.24 months at baseline, SD = 0.31; 53.5% female) further broke down restrictive feeding into restrictive amount (i.e., “I carefully control how much my child eats”) and restrictive diet quality (“I let my child eat fast food”). Scores for restrictive diet quality were associated with higher weight-for-age z-scores at subsequent time-points, reduced risk of inappropriate feeding (age inappropriate feeding of liquids and solids), and increased odds of breastfeeding (Thompson et al., 2013). This study also examined pressuring feeding style, which was conceptualized as the parent pressures their child to finish food, adds cereal to an infant’s bottle to increase intake or promote sleep, and uses food to soothe. When parents had higher ‘pressure to finish’ scores, their infants had higher weight-for-age z-scores at subsequent visits. Higher ‘pressuring with cereal’ scores predicted lower sums of skinfolds and were also related to increased odds of inappropriate feeding (Thompson et al., 2013).

It is important to note that the literature also suggests that the relation between child weight and feeding styles is bidirectional (Jansen et al., 2014; Rodgers et al., 2013; Thompson et al., 2013) with higher child weight being related to more restrictive feeding practices over time and lower child weight predicting higher levels of pressuring to eat (Jansen et al., 2014; Rodgers et al., 2013; Thompson et al., 2013). In a population-representative study of 4166 children (*m[baseline]* = 2 years; 50.3% female), from a larger sample of 7295 children in the Netherlands, researchers found that the relation from child weight to feeding practice was stronger than the prospective link from feeding to weight (Jansen et al., 2014). Additionally, parental monitoring of diet at age 2 did not predict BMI at age 6 in this study when controlling for covariates (sex, national origin, maternal BMI in early pregnancy, and highest maternal education level attained). An Australian study of 323 infants (*m[baseline]* = 1.5-2.5 years) and their mothers found that maternal monitoring of child diet predicted a decrease in food approach behaviors one year later, but this was not related to changes in BMI (Rodgers et al., 2013).

The literature is inconclusive on how feeding practices change over time. In an ethnically and socioeconomically diverse sample of 2516 adolescents (younger cohort: *m* = 12.8 years, SD = 0.8; older cohort: *m* = 15.8 years, SD = 0.8) who were followed over five years, parental encouragement to eat healthy, be active, and diet decreased for the younger cohort. In the older cohort, parental encouragement for all behaviors also decreased for males, but parental encouragement to diet increased for females (Bauer, Laska, Fulkerson, & Neumark-Sztainer, 2011). In contrast, monitoring, pressuring to eat, and restriction were found to be stable from ages 2 to 5 in a British sample of 31 children (51.6% female) (Farrow & Blissett, 2012).

5.3 Parental modeling.The literature we identified provided inconsistent support for a link between parental modeling of health behaviors and childhood obesity (Arcan et al., 2007; Timperio et al., 2008). However, the broader literature generally supports a relationship between parental modeling and children’s health behaviors, particularly eating behaviors and physical activity (Bauer et al., 2011; McClain, Chappuis, Nguyen-Rodriguez, Yaroch, & Spruijt-Metz, 2009). Two studies in our search demonstrated the impact of actual parental dietary intake on child dietary intake. Parent’s intake of dairy was found to predict dairy intake for females at 5-year follow-up in a sample of 509 adolescent-parent dyads (*m[younger cohort]* = 13 years, *m[older cohort]* = 16 years; 57% female) (Arcan et al., 2007). A study of 727 Belgian children (*m* = 10 years; 52% female) found a positive association between parental soft drink consumption when the child was 10 years old and the child’s own soft drink consumption at age 16 (Verloigne et al., 2013).

A number of studies support a link between parental eating behaviors on child eating behaviors and body weight. A study of 197 non-Hispanic White girls (*m* = 5 years) and their parents assessed the families every two years until the girls were 13 years old (Francis et al., 2007). Parental disinhibited eating was measured through a questionnaire and daughter’s disinhibited eating style was measured through an observational task. Mothers’ disinhibited eating at study entry was significantly and positively related to their daughters’ disinhibited eating at ages 9, 11, and 13; there was no significant relationship between fathers’ disinhibited eating and daughters’ disinhibited eating. Perhaps surprisingly, in a study of 92 children (age 3–5 years; 39% female), children with the greatest increases in body fat over six years had parents who were high on both dietary restraint (behavioral restraint, conscious control of eating) and disinhibition (lability in eating behaviors and weight) (Hood et al., 2000). Further analyses revealed that dietary restraint had a negative impact on child body fat only in the presence of high parental disinhibition and the authors concluded that this might be partially explained by parental modeling of unhealthy eating behaviors.

Only one study in our search examined the impact of parental modeling on child physical activity. Parental modeling of physical activity and sedentary behavior was not significantly associated with change in Australian children’s (*n* = 344; *m* = 10-12 years; 44% female) BMI z-score over three years (Timperio et al., 2008). However, girls in the sample who had a sibling who was physically active at least three times per week had a 0.17 unit decrease in BMI z-score after three years.

5.4 Family functioning, relationship quality, and support.In a nationally-representative sample of 10,775 adolescents (age 13 to 18 years at baseline; 52% female; 17.8% black, 12.2% Hispanic, 69.8% white; Add Health), health behaviors declined in the transition to adulthood and high levels of perceived social support from parents (feel their parents care for them and degree of closeness) was related to higher levels of health behaviors at age 13 but also with a greater loss of health behaviors by age 24 (Frech, 2012). Other Add Health studies found that living in non-traditional households (i.e., single parents, step-parent, no parent) was associated with fewer health behaviors in adolescence (Frech, 2012; Stewart & Menning, 2009). In another study using a sub-sample of 6378 adolescents from Add Health (*m* = 15.28 years at study entry, SD= 1.61) perceived parental caring (“How much do you feel that your parents care about you?”) by adolescents was related to reduced risk of excessive weight as adults in females (Crossman et al., 2006). However, having greater closeness with a parent in combination with adolescent perception that parents are trying to control dietary intake was related to increased risk for excessive weight as adults in males (Crossman et al., 2006). An Australian study of 201 mother-child dyads (child: *m* = 2-5 years, average 2.92 years, SD = 0.75; 57.7% female) found that dysfunctional mother-child interactions were concurrently associated with child food fussiness, but this relationship was not supported when examined longitudinally (Bergmeier et al., 2014). In a study of 688 8- to 11-year-old children (*m* = 9.05 years; 46.5% female) in Belgium, a less secure attachment to the mother predicted an increase in weight one year later (Goossens, Braet, Van Durme, Decaluwe, & Bosmans, 2012). Paternal attachment was not related. Relatedly, a study of 111 parent-child dyads (child age 7–15 years at baseline, *m* = 11.5 years, SD= 1.84) in Germany found that higher maternal depression and more insecure maternal attachment were associated with less weight reduction 12 months after a lifestyle intervention or having previously dropped out (Froehlich, Pott, Albayrak, Hebebrand, & Pauli-Pott, 2011).

5.5 Positive behavior support. Positive behavior support is an observable parenting practice that includes the use of positive reinforcement to increase desirable behaviors and the use of proactive structuring to promote self-regulation and desired behaviors. Positive behavior support was found to predict higher nutritional quality of meals served in the home across time in a sample of 731 ethnically diverse, low-income, parent-child dyads (child age 2 at baseline; 49% female children) (Montaño, Smith, Dishion, Shaw, & Wilson, 2015). Another study of the same sample provided support for a pathway hypothesized based on a DC model: positive behavior support at age 3 predicted higher nutritional quality of the meals served to children from ages 2 to 5, which in turn predicted less steep growth in BMI z-scores from ages 5 to 9 (Smith, Montaño, Dishion, Shaw, & Wilson, 2015).

**6. Distal Ecological Influences**

Harrison et al. (2011) proposed an ecological model integrating the latest research findings into a comprehensive and developmentally flexible model. As identified in this study, childhood obesity is influenced by biological and genetic factors, child characteristics, and the family context. It is necessary to underscore that these factors exist within systems including neighborhoods, institutions, communities, and macrosystems such as culture, values, and the broader economic and political environment. For example, characteristics of the biophysical and built environments, including neighborhood safety, proximity of supermarkets, and lower population density have been found to be closely related to child BMI (Dunton et al., 2012). A systematic review of these environments, however, found that most studies are cross-sectional and that findings were inconsistent (Dunton et al., 2012). This review also found that associations were moderated by gender, age, SES, and population density. A review of the etiology of childhood obesity cited two studies that found that lower priced fruits and vegetables have been related to lower BMI in youth and availability of high-caloric foods in schools has been related to higher BMI respectively (Spruijt‐Metz, 2011). This review also reported that there have been inconsistent findings between exposure to fast-food in neighborhoods and BMI although exposure has been related to diet (Spruijt‐Metz, 2011). However, residing in a rural area was associated with lower BMI in a study of Australian children in (*n* = 1373; *m[baseline]* = 7.6 years; 50% female; Health of Young Victorians Study) (Hesketh, Carlin, Wake, & Crawford, 2009). In a second study of Australian adolescents (*n* = 798; *m[baseline]* = 9 years; 52.5% female), lower BMI among girls at age 12 was associated with higher SES (as measured by standards set by the Australian Bureau of Statistics based on the “relative urban advantage of the current address”; (Burke, Beilin, & Dunbar, 2001). However, this relationship was not significant at age 15 or 18.

Cultural factors also impact the development and maintenance of childhood obesity. In a subsample (*n*= 8613; *m* = 15.93 years; 78.1% Non-Hispanic White*,* 13.4% Mexican/Chicano, 4.6% Puerto Rican, 3.9% Cuban; 49.5% female) of Add Health, Gordon-Larsen et al. (Gordon-Larsen, Harris, Ward, & Popkin, 2003) found that acculturation and proximate factors (i.e., physical activity/inactivity, diet, and smoking) predicted the lower likelihood of overweight among foreign-born Hispanics. Longer US residence was also found to be associated with increased overweight in Puerto Ricans and Cubans. Cultural and social norms also impact child weight through beliefs about portion sizes and ideal body types (Harrison et al., 2011). State and federal policies establish regulations that impact resources and practices. These policies impact costs of healthy foods, food made available at schools, and what foods are marketed to children, which in turn influence child diet and adiposity (Harrison et al., 2011; Kraak, Liverman, Koplan, & Institute of Medicine and National Academies, 2005).

1. Five studies included in the final sample were excluded from the discussion in the text because of a focus on dieting with the intention of weight loss. Although not a prospective test of an intervention, we elected to exclude them because the results may not represent normative developmental relationships between eating habits/nutritional intake and weight gain/BMI. [↑](#footnote-ref-1)
2. Assessed using the Child Feeding Questionnaire. [↑](#footnote-ref-2)