An analysis of social-ecological elements influence on weight gain in children from Alabama.

by

Priscilla Ayine
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Approved by

Geetha Thangiah, Chair, Associate Professor of Nutrition
Donna Burnett, Assistant Professor of Nutrition
Ramesh Jeganathan, Bruno Endowed Professor of Nutrition
Imran Rahman, Associate Professor of Nutrition
Linda Gibson-Young, Associate Professor of Nursing

Abstract

Childhood obesity generally tracks through the life course of an individual and is related to the increased risk of metabolic and chronic disease later in life. Additionally, excess weight during childhood increases chances of developing chronic conditions such diabetes, heart disease, and certain forms of cancer later in life. Treating obesity and its related conditions is estimated to cost the United States about $190 billion in 2005, which is said to have doubled compared to previous estimates.

This dissertation examines the cumulative effects of several risk factors that contribute to childhood obesity. We first explored the relationship between sleep timing, television exposure, and dinner time with children's weight gain. It was revealed that there was a significant increase in BMI of children who went to bed late compared to those who went to bed early regardless of having the same sleep durations, indicating that BMI increases in children may be dependent on sleep timing and not sleep duration. Exploring television exposure and dinner time also showed that longer television exposure and late dinner timing corresponds to higher BMI of children.

Furthermore, we investigated the association between children's BMI and the factors of the child-feeding questionnaire (CFQ), as well as examining the influence of maternal education. The findings indicate that children's BMI was positively associated with perceived child weight and parental concern and negatively associated with pressure to eat. Additionally, we found that the parental feeding practice factor (pressure to eat) was the only factor dependent upon maternal education.

And finally, we explored the differences in children's eating behaviors and maternal education in relation to child weight status using the child eating behavior questionnaire. The results indicates that children with obesity exhibited a significant increase in food responsiveness, enjoyment of food, emotional overeating, and a decrease satiety responsiveness compared to normal weight children. Furthermore, we observed high mean scores among food approach subscales in low maternal education levels compared to food avoidance subscales. Indicating that low maternal education may be susceptible to children's behaviors that involve interest in food compared to mothers with higher levels of education.

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List of Abbreviations

BMI	Body Mass Index
CDC	Centers for Disease Control and Prevention
EE	Early bed/Early wake-up
EL	Early bed/Late wake-up
LE	Late bed/Early wake-up
LL	Late bed/Late wake-up
CFQ	Child Feeding Questionnaire
PR	Perceived Responsibility
PPW	Perceived Parent Weight
PCW	Perceived Child Weight
CN	Concern about Child Weight
RST	Restriction
PE	Pressure to Eat
MN	Monitoring
NW	Normal Weight
OW	Overweight

OB	Obesity
CEBQ	Child Eating Behavior Questionnaire
FR	Food Responsiveness
EOF	Enjoyment of Food
DD	Desire to Drink
EOE	Emotional Overeating
SR	Satiety Responsiveness
FF	Food Fussiness
EUE	Emotional Undereating
SES	Socio-Economic Status
WHO	World Health Organization

Chapter 1: Introduction

1.1 Research Problem

Childhood obesity has become one the world's most serious public health challenges in countries of different income levels [1,2]. Its prevalence has been steadily increasing especially in middle and high- income level countries [3-5]. It has been reported the total number of children under five with overweight and obesity has increased from 32 million in 1990 to 41 million in 2016 globally and it is expected to reach 70 million by 2025 [6,7]. If left untreated, children with obesity usually go on to become adults with obesity [8], and subsequently, develop a variety of health problems including diabetes, cardiovascular disease, non-alcoholic fatty liver disease, musculoskeletal disorders, certain forms of cancer, psychological health issues and many more [9,10]. Additionally, though the prevalence of childhood and adolescent's obesity did not change between 2007-2008, the prevalence of obesity among 2-5 years (12.1%), 6-11-year-olds (18.0 %), and 12-19-years (18.4%) remains at an all-time high [11]. Nevertheless, it should be noted that some epidemiological studies show that the incidence of childhood obesity is continuing to rise in certain sex, age, ethnic, and socioeconomic status groups within the United States and would contribute to the increase in the number of adults with obesity [12,13].

1.2 Statement of Purpose

The mechanism of obesity development is thought to be caused by multiple elements, such as genes, sugary beverages, high caloric food, sedentary behaviors, environmental factors, sociocultural factors, family factors and psychological factors. Therefore, the purpose of this study was to:

i. To investigate the relationship between obesity and sleep timing patterns, television exposure time, and dinnertime among elementary school-age children.
ii. To assess parental perceptions, concerns about weight, feeding practices using the Child Feeding Questionnaire (CFQ), and its association with body mass index (BMI) and maternal education in elementary school children.
iii. To examine the association between the CEBQ and child weight status and the differences in child appetite characteristics in relation to children's body weight and maternal education level.

1.3 Research Questions

1. What is the relationship between obesity and sleep timing patterns, television exposure time, and dinnertime among elementary school-age children?
2. What are parents' perceptions, concerns, and feeding practices related with the obesity of children?
3. Are CFQ factors associated with maternal education?
4. What are the differences in children's eating behaviors and their relation to weight status and maternal education level, using the child eating behavior questionnaire (CEBQ)?

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Chapter 2: Review of Literature

2.1 Prevalence of Global Obesity

The global prevalence of obesity has almost tripled between 1975 and 2016, and the world Health Organization (WHO) estimates that 2 billion adults are overweight worldwide, of which about 650 million are considered obese (BMI ≥30 kg/m2). That is equivalent to 39% of adults aged 18 and above being overweight and 13% obese. Obesity is defined using body mass index (BMI) to classify whether an individual falls under the category of underweight, healthy, overweight, or obese. BMI is simply an index of weight -for-height used in classifying these categories [1].

A recent analysis predicted that by 2030, an estimated 2.16 billion adults will be overweight and 1.12 billion estimated to be obese globally [2]. Obesity has become one of the world's largest public health challenges, which now does not only affect developed countries but spans across countries with varied economies worldwide. Obesity is a risk factor for numerous leading causes of death, including heart diseases, stroke, diabetes, and various types of cancer [1]. Though obesity is not a direct cause of these health conditions, it is reported to increase their likelihood of occurrence [1].

Globally, it is reported that 8% of deaths in 2017 were the result of obesity which is an increase from 4.5% in 1990. The prevalence of obesity is generally rising globally but clearly higher across developed countries compared to less developed countries as shown in Figure 1.[3]

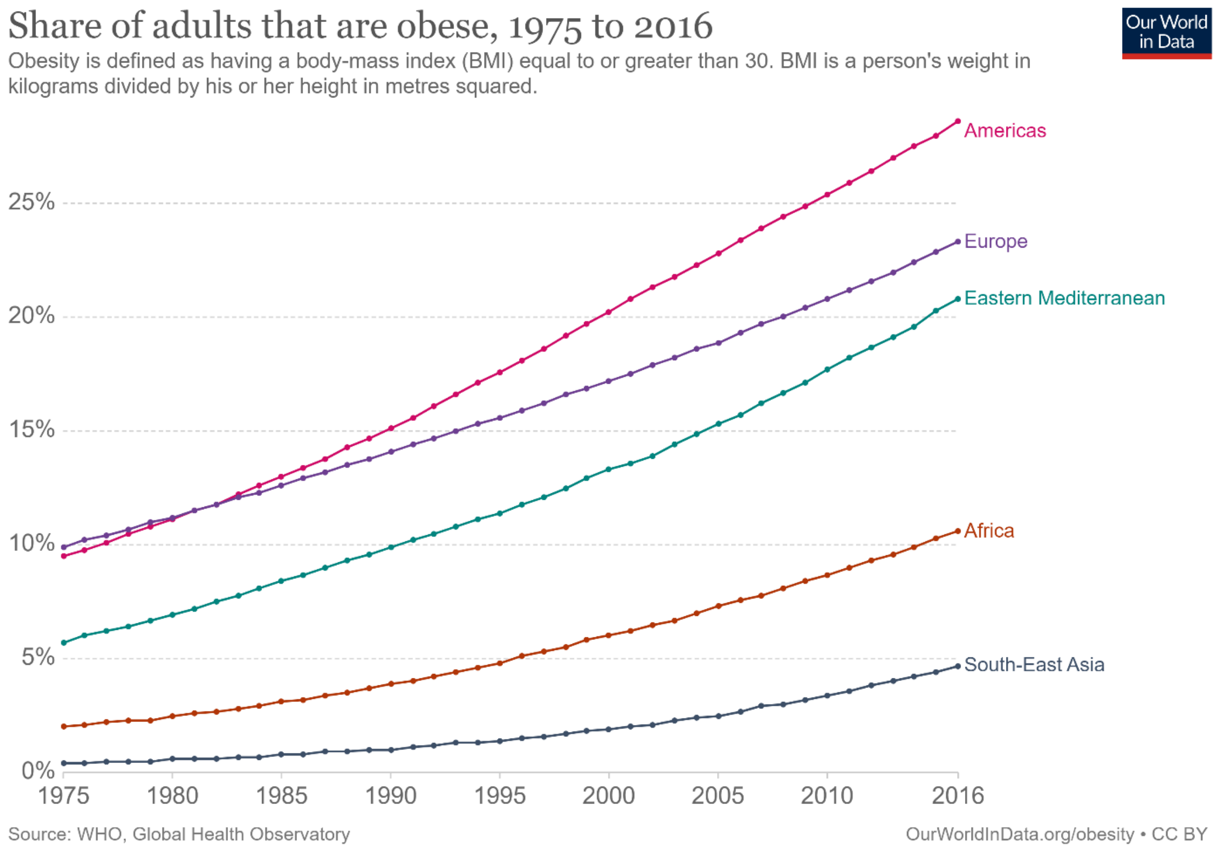

Figure 1. Global Adult Obesity Prevalence [3]

Generally, a pattern is observed between adult obesity with higher-income countries: the prevalence of obesity tends to be steadily rising across the world but significantly higher in richer countries across Europe, Americas, and Eastern Mediterranean. And much lower rates observed across South Asia and Sub-Sub-Saharan Africa where income levels are generally lower.

In addition, obesity in these high-income countries is usually found in rural areas and typically among the poor, which is a reverse in low-income countries [3]. Over a few decades now, there have been a remarkable shift in the way entire global populations eat, drink, and move. These changes have conflicted with human biology to produce important changes in body composition [4,5]. For instance, more than a few decades ago, it was heresy to discuss a looming global pandemic of obesity in the United States [6]. Nevertheless, diets and activity patterns were evidently changing drastically due to the rise of fast-food restaurants and fewer opportunities for walking, and by the 1980's it was noticeable that dietary quality and physical activity in the United States was severely deteriorating, and obesity was gradually rising across the United States [6].

2.2 Prevalence of Obesity in the United States

The obesity epidemic is steadily on the rise despite the awareness and efforts to combat it [7]. The United States has especially been affected by this epidemic, as it has been reported by the Center for Disease Control and Prevention (CDC) that more than half of all states had an adult obesity prevalence of over 30% as at 2018 [8] as shown in Figure 2. The obesity epidemic is hypothesized to be because of the intersection of centuries of evolutionary demands put on humans to maximize metabolic efficiency with the prevalence of caloric dense, palatable food in the contemporary world [6].

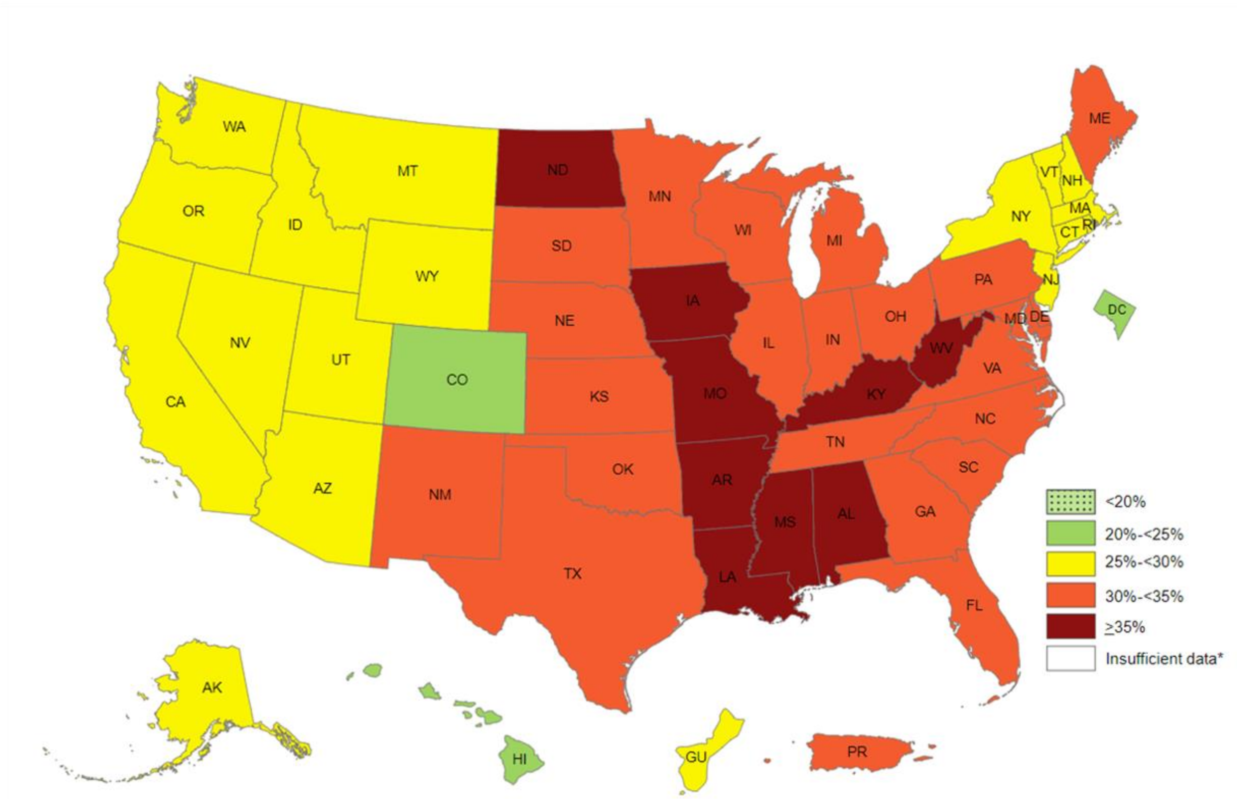

Figure 2. Prevalence of Self-Reported Obesity Among U.S. Adults by States and Territory [8]

Prevalence of obesity is predicted to reach 42% by 2023 [9] and given that obesity increases the risk of chronic disease [10], and according to the recent Behavioral Risk Factor Surveillance System (BRFSS) data, adult obesity has exceeded 35% in 12 states, 30% in 35 states, and 25% in 48 states. Mississippi has the highest rates of adult obesity at 40.8%, whilst Colorado and DC have the lowest rates at 23.8%. It’s reported that, between 2018 and 2019, there was a rise in adult obesity rates in Michigan and Pennsylvania, decreased in Florida, while remaining stable in the remaining states and District of Columbia [11]. Though the growth trends in overall obesity in most developed countries appear to level off [12], morbid obesity in several of these countries continue to rise significantly, including children.

2.3 Defining Childhood Obesity

According to a national composite index developed by the Foundation for Childhood Development [13], the general health and well-being of children is 37% lower in present times compared to the mid-1970s. And one of the largest contributors to children's deteriorating health is obesity [13]. W.H. O estimates that the prevalence of children below age 5 years old with a BMI in the 98th percentile increased from 4.2 % in 1990 to 6.7% in 2010, and this is expected to reach 9.1% in 2020 [14]. The incidence of childhood obesity has tripled in children and adolescents in the United States since the 1980s [15], indicating that it may be increasing at a faster rate compared to adult obesity with key consequences for the population's future health. Increase in obesity rates have been observed in children and adolescents, and this trend has been predicted to continue, as shown in Figure 3. [15]

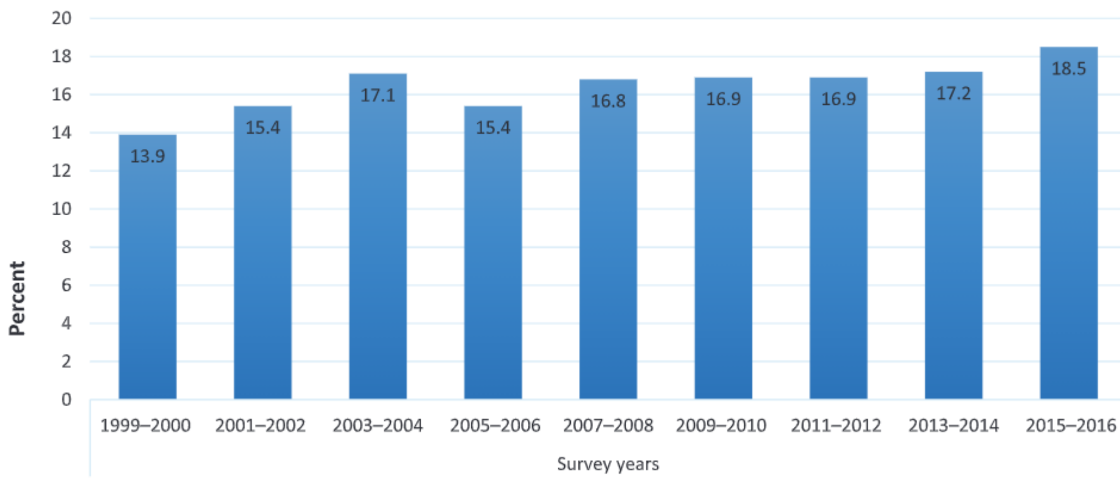

Figure 3. Trends in obesity prevalence among children and adolescents aged 2 to 19 years: The United States, 1999 – 2000 through 2015 – 2016 (15).

Obesity occurs because of a chronic caloric imbalance, where higher number of calories are consumed than expended daily. Family history of obesity, genetic factors, environmental factors, metabolism, behavior, culture, and socioeconomic status are factors that contribute to obesity [16]. The origins of adult obesity have been traced to early childhood development, as illustrated in figure 4 [17].

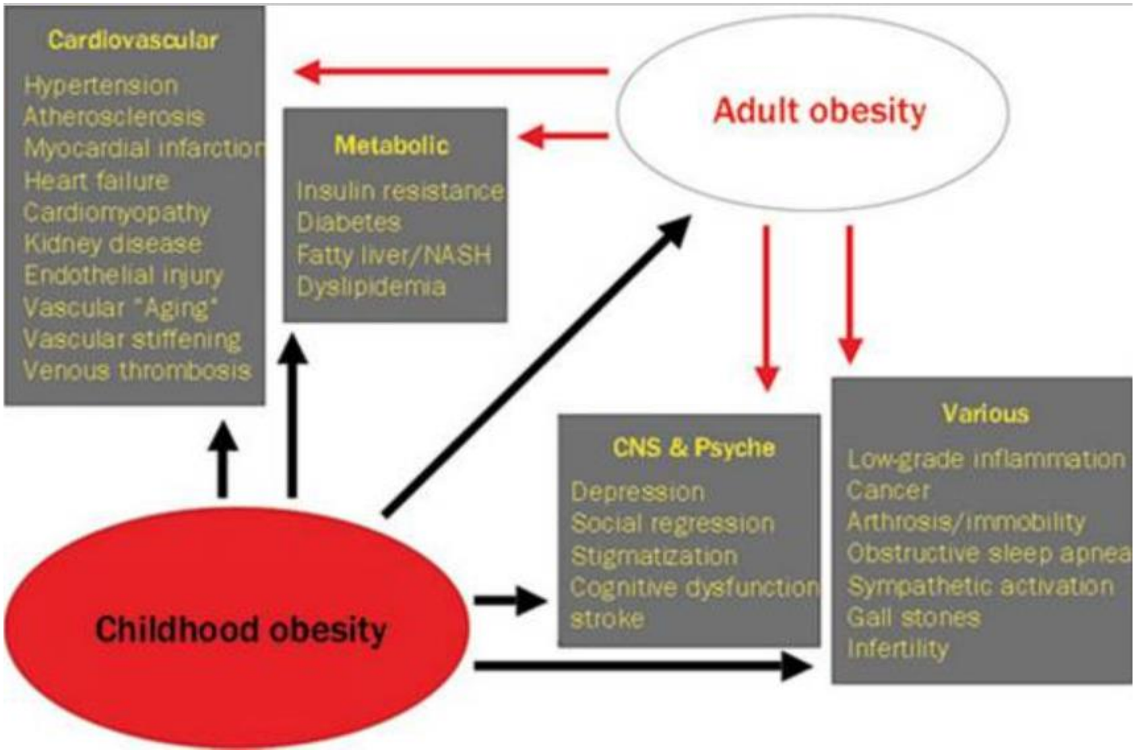

Figure 4. Effects of childhood obesity on the long-term risk for adult obesity and other disease conditions [16].

Study findings have shown that children who are overweight or have obesity are more likely to be overweight/obese in their adolescent years well into adulthood [18], thereby the need to give credence to childhood obesity research. According to findings from previous studies, evidence suggest that children who experience adiposity rebound (adiposity rebound is the inflexion point of BMI percentiles between the age of 3 and 7 years) at an early age is at higher risk for obesity in later life [19,20].

According to CDC, BMI is the measure used to define childhood overweight and obesity. And BMI is assessed by dividing a person's weight in kilograms by the square of height in meters. Childhood obesity is defined as a BMI above the 95th percentile for age and sex (and >85th percentile for overweight). For children and teenagers, BMI is age-and sex-specific, often referred to as BMI-for-age. A child's weight status is determined using an age -and sex-specific percentile for BMI rather than the BMI categories used for adults. This is because children's body composition changes as they age and varies between boys and girls. Therefore, the need for children's BMI levels to be expressed relative to other children of the same age and sex [8].

Recent estimates by the National Health and Nutrition Examination Survey indicate that one third of children in the United States are either overweight or obese, with about 18% falling into the category of obesity according to BMI measurements [21]. It has been estimated that around 40 million children under the age of 5 years and more than 330 million children and adolescents aged 5-19 years were overweight or obese in 2016 [22]. Given the cascade of health consequences excess weight poses to children, the member states of WHO endorsed the "no increase in childhood overweight by 2025" as one of its six global nutrition targets in the 'Comprehensive Implementation Plan for Maternal, Infant and Young Child Nutrition' [23]. This is consistent with the same target for obesity and diabetes between 2010 and 2025 in the 'WHO Global Action Plan for the Prevention and Control of Non-communication Diseases 2013-2020' [1,24].

Childhood overweight or obesity has very critical short-term and long-term health outcomes. In the short-term, children who are overweight or obese are susceptible to suffering psychological comorbidities including depression, anxiety, low self-esteem, emotional and behavioral disorders [25,26], asthma, low-grade systematic inflammation [27,28], liver complications, and musculoskeletal problems, especially in the lower extremities [29]. In addition, children with obesity or overweight have higher risk factors for metabolic and cardiovascular conditions [30] such as high blood pressure, hyperlipidemia, respiratory conditions, as well as asthma or sleep apnea [27], and many other chronic conditions. In addition, people with obesity are susceptible to stigmatization, which leads to decreased self-esteem and an overarching reduced quality of life [31].

The state of Alabama is ranked the sixth highest in adult obesity rates in the United States. Additionally, it is estimated that about 35.5% of children are overweight and obese in Alabama. However, studies in some of Alabama's rural school reveal that, more than 50% of the children are overweight/obese [32] compared to that of 30.6% nationwide. The CDC suggest that an increase in the incidence of childhood obesity in Alabama may be attributed to a lack of breastfeeding, unhealthy diet, physical inactivity, and environmental conditions [33].

Given the intricate nature of obesity, there is evidence indicating several factors contribute to the rising rates of childhood obesity, therefore, is unlikely there is ever going to be one treatment regime or an intervention that is suitable for all factors contributing to obesity. Therefore, this study will examine some risk factors that contribute to childhood obesity, to contribute to the understanding of the etiology of childhood obesity and help inform prevention and intervention strategies.

2.4 Risk Factors for Childhood Obesity

The present knowledge gap about childhood obesity is not about the number of risk factors, nor their impact on increasing the obesity risk, but rather in how they cumulatively interact to influence what has come to be known as the "obesogenic" environment. Obesity is a prolonged multifactorial disease, presented by an excessive accumulation of adipose tissue, usually because of excessive food intake with or without low energy expenditure [34]. Though at the simplest, obesity is considered to result from consuming more calories than the body can burn. This energy imbalance is partly a result of an intense social and economic changes at levels beyond an individual's control [34].

These obesogenic factors such as economic growth, growing availability of caloric dense food, industrialization, mechanized transportation, and urbanization occur in high-income countries since the early 20th century, and currently these factors are increasing in low-and middle-income countries. However, not everyone living in this obesogenic environment experience weight gain and obesity [35], therefore, several other factors have been identified to contribute to obesity including genetic, psychological, lifestyle, nutritional, environment, and hormonal factors [36]. While these factors identified play a complex role in weight gain, personal behaviors in response to these factors ultimately have a dominant role in preventing obesity in children. Most especially, the risk factors discussed below are modifiable except genetics.

2.4.1 Energy Balance

The simplest way of explaining weight gain is usually looked at in terms of altered energy balance, which includes energy intake, energy expenditure, and the storage of surplus energy in the form of triacylglycerol within tissues [37]. Body weight changes because of energy intake exceeding energy expenditure over a period. Humans derive energy in the form of carbohydrate, protein, fat, and alcohol (energy in (EIN)) and expend energy (energy out (EOUT) through several metabolic processes including resting metabolic rate (RMR), which is the energy required to fuel the body at the state of complete rest. This RMR energy is used to perform essential functions such as breathing, circulating blood, or executing brain functions. Next is the thermic effect of food (TEF), defined as the cost of energy used in absorbing and metabolizing food consumed. And finally, energy expended through physical activity (EEPA). Among these metabolic expended processes, physical activity associated energy expenditure (EEPA) is the most changeable element of energy expenditure compared to RMR and TEF [38]. Because, unlike EEPA which entails the amount of physical activity multiplied by the energy cost of that activity, RMR is proportionate to body mass, mostly the amount of fat-free mass and TEF being proportionate to the total food consumed [37].

2.4.2 Diet

In the decades prior to the 21st century, most of the research on obesity risk factors focused on individual level, largely adjustable behaviors. The role of diet and physical activity in alleviating obesity risk and reducing obesity prevalence have received the most attention. In the United States about 15% of deaths in 2000 were attributable to excess weight, due to poor diet and physical inactivity [39]. Caloric intake and energy expenditure required for weight maintenance or healthy growth has historically assumed center stage, and caloric restriction has remained a key focus of most popular clinical weight -management and weight-loss approaches [37].

Beyond caloric intake to control body weight, an enormous amount of research has attempted to tackle the roles of diet quality and dietary patterns, including those specifying combinations of macronutrients [40]. Data from clinical trials suggests that caloric restriction regardless of dietary pattern is associated with better weight loss and maintenance outcomes [40]. While the metabolic nuances and relative merits of varying dietary patterns for numerous comorbid conditions are still being explored, the evidence appears to suggest that simply sticking to a calorie deficit diet, regardless of the type of healthy diet, has an impact on weight loss or maintenance [40-42].

To maintain a healthy weight, observational cohorts' studies suggest that diets that are deemed "healthier" lead to improved long-term weight maintenance, or at least alleviate weight gain usually associated with aging through middle age [43]. For instance, studies in US health professionals revealed that an averaged 4-year weight gain through middle age was strongly correlated with increasing intake of high caloric foods such as potato chips, sugar-sweetened beverages, processed, and unprocessed meats etc., but inversely correlated with the intake of vegetables, fruits, whole grains, nuts etc. [43]. Certain food groups, such as sugar-sweetened beverages, have gotten significant amount of attention mainly because added sugar consumption (mostly sugar-sweetened beverages) has been increasing concurrently with obesity prevalence [44]. Undeniably, the evidence about the role of sugar-sweetened beverages play in obesity [45,46] is a strong incentive for public health interventions and policies, such as limiting marketing on these beverages as in the attempts made to limit beverage sizes allowed for sale as in New York City [47,48], taxation, eliminating sale in schools, etc.

2.4.3 Socioeconomic Factors (Income and Education)

Income has had a changing role in the risk of obesity over the last century. In the late mid-20th century, the Unites States and Europe could directly link wealth with obesity. For instance, A wealthy individual was more likely to be overweight or obese in the late mid-20th century in those countries. However, over the last few decades, probably due to the abundance of cheap and highly available caloric dense food, combined with shifting sociocultural norms, this link has reversed. Currently in the United States, wealth tends to be inversely correlated with obesity, and it is those who are at or below the poverty level appear to have the highest rates of obesity [49].

For instance, across eleven Organization for Economic Co-Operation and Development (OECD) countries, and Socio-Economic Status (SES), regardless of whether household income or occupation-based social class, revealed an inverse relationship with obesity. Women with low SES particularly had consistently higher incidence of overweight/obesity compared to their affluent counterparts [50]. In the case of men, those in low-income levels tended to have higher incidence of obesity, but the gradient for overweight reversed in about half of the countries surveyed. Results in the surveyed countries revealed that in some countries, poverty was associated with high prevalent overweight compared to wealth, whilst in others, lower income was associated with more favorable weight status [50]. The difference observed between sexes in terms of income status and obesity, particularly the trend reversal in men could be in part due to low-paying jobs typically physically demanding work performed by men than women [50]. Furthermore, education level may play a role. In the 11 OECD countries discussed earlier, education showed a strong inverse relationship with overweight/obesity, particularly in women who had less education had consistently higher prevalence of overweight/obesity compared to those with a high level of education [51].

In exploring the role of education and wealth in women and weight status in four middle-income countries (Colombia, Peru, Jordan, and Egypt), researchers observed a significant interaction between education and wealth. In women with little or no education, higher income was related with 9-40% higher odds of obesity, while in those with high level levels of education the association with income was either not present (Egypt, Peru) or associated with 14-16% lower odds of obesity (Jordan, Colombia) [52].

These findings suggest that at presently transitioning economies, education may compensate for the seemingly negative effects of increasing purchasing power in obesogenic environments. However, the protective effect of education has yet to be observed in countries such as India, Nigeria, and Benin, where both education and wealth were directly linked with increased odds of obesity [52]. This perhaps was anticipated given that obesity was relatively rare at <6% of women in these countries, and >50% of women had little to no education. The flicker of hope, then, is the context of a paradigm of diseases of wealth, in which the transition to wealth seems to unvaryingly lead to rising obesity rates and thus greater chronic disease burden, higher education levels may yet again compensate for some of the terrifying challenges that are ahead of us.

2.4.4 Maternal Education

Parental characteristics have been shown to be very important determinants of children's development and health behaviors [53]. Previous studies have also revealed that maternal characteristics have even stronger effects on children's development and health status compared to parental characteristics [54,55]. Mothers play a vital role in children's health outcomes and the development of children. Due to the importance of maternal characteristics, maternal educational level has been shown to play an essential role in determining a child's health status [54,56-58]. Findings from several studies have revealed that mothers with lower education levels fed their children with less healthy foods [55,59], which resulted in negative health outcomes for their children. Another study found that mothers with higher education are more likely to initiate early breastfeeding for their newborn babies [60].

Furthermore, higher educational achievement among mothers may reduce the child's susceptibility to the cumulative nature of obesogenic factors, through more use of positive parenting practices and improved attainment of the familial and residential environment, and a reduced possibility of other disadvantages, such as belonging to a single parent family and living in poor household or communities [61,62].

Therefore, it is important to explore the relationship between mother's education level and children's weight status.

2.4.5 Sleep, Sedentary Behaviors, and Physical Activity

In addition to diet, lifestyle behaviors diet such as physical activity, sleep, sedentary, and screen time have also been independently correlated to changes in weight and maintenance of a healthy weight in adulthood. Paired with diet, these factors have synergistic and possible cumulative effects on a person's capability to obtain and keep a healthy weight over the period of a lifetime. Evidence from recently reviewed randomized trials and observational studies suggest that a consistent 150 – 250 minutes per week of moderate to intensive activity is needed to avoid weight gain or assist in weight loss when done with dietary restriction involving calorie deficit [63,64]. Activity of more than 250 minutes per week has been found to be associated with losing weight and keeping it off after weight loss [64].

Furthermore, leisure-time activities including sitting for prolonged periods of time, television viewing or general screen, and other sedentary behaviors have been associated with gain [43,46,65]**.** Additionally, sleep timing patterns have been found to contribute to obesity risk in children [66].

2.4.6 Parental Perception and Feeding Practices

Most parents have been found to perceive their children's weight and showed an enormously high amount of concern when their child gains weight [67], therefore, it is increasingly understood that parent's perceptions of their children's weight status is an essential factor when developing public health interventions to cut down on the prevalence of overweigh/obesity [68].

Parents play a key role in the development of healthy eating behaviors, food values, and preferences in children, as these factors directly impact their health. Children's health largely depends on the nutritional habits formed in the earlier stages of their life [69]. Lifestyle and diet are modifiable risk factors associated with childhood obesity; therefore, preventive interventions should be targeted towards changing these behaviors [70]. Intended interventions to reduce the risk of childhood obesity should be begin prior to school years as this gives parents ability to make significant decision over what children eat and activities to maintain a healthy weight [71].

2.4.7 Child Eating Behaviors

Individual eating styles have been theorized to contribute to both undernutrition and overnutrition. Eating behaviors of children such as eating in response to environmental food cues increase the risk of children gaining weight [72,73], while responsiveness to internal satiety cues and fussiness have been found to be associated with losing and maintaining weight [74,75]. Several eating styles concepts have been linked to the etiology of weight gain and obesity in general. People with obesity have been hypothesized to respond less to internal satiety cues but have a high response to external food cues such as smell [76], and reacting fast in responding to emotional arousal, thereby outpacing the inception of satiety during the meal [76].

Several other behavioral studies have suggested that children's eating behavior and appetite-related traits are related to BMI [74,75]. Furthermore, it has been found that parents exert a crucial influence on children’s eating patterns and weight gain through their own eating behaviors and feeding practices [76,77].

2.4.8 Genetic Component

Despite the rising prevalence of obesity being partly explained by environmental changes, over the past decades there is compelling evidence suggesting a genetic factor to the risk of obesity [78,79]. Genetic factor for obesity is reflected in the differential prevalence in racial groups, as studies has reported 5% or less in Caucasian and Asian populations compared to 50% or more among Pima Indians and South Sea populations [80]. Additionally, the hereditary incidences of obesity have been noted for a while now with the concordance for fat mass amongst monozygotic (MZ) twins stated to be 70-90%, higher than the 35-45% reported in dizygotic (DZ) twins; as such, the projected heritability of BMI ranges from 30 to 70% [30,78,81].

In conclusion, obesity is complex and is caused by an interplay between environmental and genetic risk factors as discussed above. Obesity is a major contributor to chronic diseases and death across the globe. Obesity also causes a major decrease in quality of life and increases medical spending. With a myriad and compounding nature of its risk factors, there is urgent need to deeply understand the interplay of these risk factors and to design appropriate solutions to prevent and treat obesity.

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Chapter 3: The relationship between obesity and sleep timing behavior, television exposure, and dinnertime among elementary school-age children

3.1 Abstract

The daily lifestyle behaviors of children have been shown to be associated with obesity. There are limited studies on the association of sleep timing behavior and body mass index (BMI), specifically in elementary school-age children. This study aimed to investigate the relationship between obesity and sleep timing patterns, television exposure time, and dinnertime among elementary school-age children. Children (n = 169) aged 6 to 10 years who were residents of Alabama were recruited for this study. The questionnaires were used to determine the bedtime, wake-up time, television exposure time, and dinnertime of the participants. The participants were categorized into four groups depending on the bedtime and wake-up time behavior habits: early bed/early wake-up (EE); early bed/late wake-up (EL); late bed/early wake-up (LE); and late bed/late wake-up (LL) time. The BMI z-score, television exposure time, and dinnertime of these groups were compared. The LL group had a significantly higher BMI z-score compared to the EE group. The higher BMI z-score in the LL group may be associated with late bedtime and not late wake-up time. Approximately 71% of children with late bedtime (8:48 PM), 75% of children who watch television for more than 1 hour, and 54% of children who have dinner after 7:00 PM have obesity. Daily behavior habits such as late bedtime, increased television exposure, and late dinnertime are associated with obesity.

Keywords: body mass index, childhood obesity, dinnertime, sleep timing, television exposure

3.2 Introduction

Childhood obesity is a public health concern for a variety of reasons. In the United States, approximately 12.7 million children and adolescents are classified as obese [1]. The prevalence of obesity is 8.9% among children aged 2 to 5 years, 17.5% for those age 6 to 11 years, and 20.5% for those age 12 to 19 years. The annual medical cost related to obesity is estimated to be $254 billion [2]. There are several known factors that could contribute to an increase in the prevalence of childhood obesity, including sedentary activities, media influence, socioeconomic status, food availability, parental influences, and cultural considerations. Children with obesity experience immediate and lasting consequences on physical, social, and emotional health. They have a higher likelihood of other chronic health conditions and diseases that affect physical health such as type 2 diabetes, cardiovascular disease, and cancer [1,3,4]. The Centers for Disease Control and Prevention (CDC) suggest that approximately 35.5% of children are overweight and obese in Alabama, a state ranked as having the sixth highest rate of obesity in the United States.

According to the CDC, an increase in the prevalence of childhood obesity in Alabama may be attributed to a lack of breastfeeding, unhealthy dietary habits, physical inactivity, and environmental conditions. Short sleep duration has been shown to increase the risk of childhood obesity [5,6]. Sleep is essential for several biological processes that are necessary for providing optimal physical and mental health. Short sleep duration is a widespread problem across cultures [7]. However, studies have shown that the link between short sleep duration and obesity in children is more complicated than initially believed [8,9]. No association was found between sleep duration and body mass index (BMI) in a longitudinal study of United States adolescents [10]. Few studies have reported that sleep timing behavior (bedtime and wake-up time) rather than sleep duration is associated with obesity [11]. Children with a late bedtime and late wake-up time had a higher risk for obesity compared to those with early bedtime and wake-up routines in a study conducted in Australian children [12]. Children with early wake-up times have a lower BMI compared to children with late bedtimes [13,14].

Children exposed to extended television viewing have a higher risk of obesity [15,16]. Television viewing reduces physical activity, increases unhealthy snacking, and hampers sleep [17]. Children are also influenced by food-related TV ads, which promote low-nutrient foods and drinks with high calorie content [18]. The time of dinner consumption may also be associated with obesity [19]. The time of food intake has shown to regulate the circadian clock at behavioral, physiological, and molecular levels [20].

The obesity-related lifestyle behavior factors are linked with each other, rather than distinct elements. Children's daily lifestyle behaviors are dependent on the family environment, especially in young children. In this study, we identified the relationship of the sleep timing pattern, television exposure time, and dinnertime with BMI in elementary school-age children.

3.3 Method

3.3.1 Participants

Approximately 169 children aged 6 to 10 years were recruited from Lee County and Macon County, Alabama, by posting flyers at after-school programs and health fairs, on Facebook, and via participant referrals. Children with major health disorders such as diabetes, cardiovascular disease, or diagnosed sleep disorder based on initial phone survey with the parents were excluded. The parents brought their child to Auburn University to participate in this study. The written consents were obtained by the parents and participants. The study was approved by the Auburn University Institutional Review Board.

3.3.2 Anthropometry

Participants' body weight was measured without shoes and with light clothing to the nearest 4 ounces using a Tanita digital scale. Their height was measured to the nearest 0.1 cm on a calibrated scale attached to a stadiometer. In accordance with the CDC growth chart, BMI was calculated based on the body weight and height obtained. The recruited participants were classified as "underweight: less than the 5th percentile; normal weight: between 5th to 85th percentile; overweight: between 85th to 95th percentile; and obese: greater than the 95th percentile [21]." As children grow from age 2 to 20 years, not all such growth is body fat, so BMI z-scores are calculated using an SPSS (IBM Corp, Armonk, New York, United States) macro based on World Health Organization growth reference 2007 data adjusted for age and sex [22].

3.3.3 Survey instrument

Parents completed questionnaires (on paper) on behalf of the participants about age, sex, annual family income ($25,000 or less, $25,001 to $50,000, $50,001 to $75,000, $75,001 or more), and child's mother's education (high school or less, some college or associate degree, bachelor's degree, graduate degree). In addition to these questions, we also asked the following: "What is the bedtime of your child?" "What time does your child wake up?" "How long does your child watch television per day?" and "What time does your child eat dinner?" Monetary compensation was provided to the participant as an appreciation for their time and support to this study.

3.3.4 Statistical analysis

Statistical analyses were performed using SPSS version 24. Continuous variables are expressed as mean ± standard error, except for television exposure time, which is expressed as mean ± standard deviation. The mean of the groups was evaluated by analysis of variance followed by Bonferroni post hoc test. Categorical variables were derived by calculating the frequencies and expressed as a percentage. The significant difference was then analyzed by either one-sample or two sample *t* tests between the percentages. Unadjusted multinomial logistic regression was used to analyze the odds ratio and association between BMI z-score and sleep behavior categories. For adjusted analysis age, sex, television exposure, and dinnertime were used as covariables.

3.4 Results

The characteristics of participants recruited for this study are shown in Table 1. The mean age of children was 8.42 years, 50.9% were female, and 49.1% were male. Of a total of 169 participants, 35.5% of children were considered overweight/ obese. Demographic data, duration of television exposure, dinnertime, maternal education, and annual household income are shown in Table 1.

A bedtime before 8:30 PM was considered as early bedtime and after 8:31 PM as late bedtime. Similarly, if the wake-up time was before 6:00 AM it was categorized as early wake-up time and after 6:01 AM as late wake-up time. Depending on the bedtime and wake-up time, the participants were classified into four groups: early bed/early wake-up (EE); early bed/late wakeup (EL); late bed/early wake-up (LE); and late bed/late wake-up (LL). The EE and EL groups went to bed 45 to 65 minutes earlier than the LE and LL groups, whereas the EE and LE groups woke up 40 to 65 minutes earlier than EL and LL groups. The sleep duration for EE (9 hours 56 minutes) and LL groups (9 hours 57 minutes) are very close. The EL group slept approximately 30 minutes longer (10 hours 23 minutes), whereas the LE group slept approximately 1 hour less. There were significant differences between the bedtime, wake-up time, and sleep duration, as shown in Table 2.

As the first step, we investigated whether bedtime or wake-up time is important for obesity. Therefore, we analyzed the differences in the BMI z-score based on bedtime only, and the participants were separated according to early bedtime (EL and EE group) and late bedtime (LE and LL group). We observed a significantly higher ($p < .0001$) BMI z-score in the late bedtime group compared to the early bedtime group (Figure 1A). Figure 1B shows the proportion of normal weight, and obese children by early and late bedtime. Only 29% of participants were obese in the early bedtime group compared to 71% in the late bedtime group ($p < .01$). Similarly, the differences in the BMI z-score based on only the wake-up time were determined. The EE and LE groups were combined as early wake-up time, and EL and LL groups were combined as the late wake-up time. There was no significant difference in the BMI z-score between early wake-up and late wake-up times (Figure 1C). Figure 1D shows the proportion of normal weight, overweight, and obese children by early and late wake-up time.

There was no significant difference in healthy and obese participants in early or late wake-up time groups. These results suggest that the participants with late bedtime after 8:30 PM tend to have a higher BMI z-score.

Next, we investigated the differences in the BMI z-score on the combination of both the bedtime and wake-up time. Figure 2A shows bar charts of the participants BMI z-score in EE, EL, LE, and LL groups. The BMI z-score is significantly increased in the LL group ($p < .007$)

compared to the EE group. The proportions of normal weight, overweight, and obese children according to sleeping habits are shown in Figure 2B. Approximately 4% of participants are obese in the EE group, 25% in the EL group, 28% in the LE group, and 43% in the LL group. Most importantly, the percentage of obesity (42.86% versus 3.57%, $p < .0009$) was significantly higher in the LL group compared to the EE group. The association between sleep timing behavior and BMI z-score is shown in Table 3. In unadjusted analysis, the LE ($p < .023$) and LL groups ($p < .002$) had higher BMI z-scores compared with the EE group. After adjustment for age, sex, television exposure, and dinnertime, the LL group still had a significantly higher BMI z-score. We then analyzed the relationship between television exposure time with BMI z-score and sleep timing behavior. The participants were separated into three groups based on their television exposure time: less than 30 minutes of exposure, 30 minutes to 1 hour of exposure, and exposure for longer than 1 hour.

The differences in the BMI z-score based on the television exposure time is shown in Figure 3A. BMI z-score is significantly higher in participants with more than 1 hour of television exposure ($p < .0001$) compared to participants with less than 30 minutes of exposure. The proportions of normal weight, overweight, and obese children by television exposure are shown in Figure 3B. Approximately 75% of participants with longer than 1 hour of television exposure are obese, 14% are obese with 30 minutes to 1 hour of television exposure, and 11% are obese with less than 30 minutes of television exposure. Children who watched television for more than 1 hour were more likely to have obesity in comparison with the other groups (75% versus 14.29% and 10.71%, $p < .0001$). Figure 3C shows the relationship between sleep timing behavior categories and television exposure. In the LL group, 30% of the participants watch television for more than 1 hour, whereas only 7% in the EE group do ($p < .02$)

Table 1. General characteristics of the study

	All (n=169)	NW (n=109)	OW (n=32)	OB (n=28)
Sex (n)				
Male	83	55	16	12
Female	86	54	16	16
Age (years)	8.42 ± 0.10	8.37 ± 0.14	8.28 ± 0.23	8.77 ± 0.28
Weight (kg)	32.22 ± 0.83	27.82 ± 0.64	34.12 ± 1.11 [a]	47.20 ± 2.69[ab]
Height (cm)	132.37 ± 0.89	130.55 ± 1.09	132.47 ± 1.60	139.34 ± 2.45[a]
BMI (kg/m^2)	17.96 ± 0.26	16.06 ± 0.15	19.31 ± 0.19[a]	23.81 ± 0.59[ab]
BMI z-score	0.70 ± 0.09	-0.02 ± 0.08	1.56 ± 0.05[a]	2.56 ± 0.07[ab]
Television time (%)				
0–30 minutes	20.09	33.94	15.63	10.71
30–60 minutes	24.79	25.69	34.38	14.29
> 60 minutes	55.12	40.37	50.00	75.00[c]
Dinnertime (%)				
Before 6:00 PM	32.34	38.53	40.63	17.86
6:00 to 7:00 PM	34.38	33.94	40.63	28.57
After 7:00 PM	33.28	27.52	18.75	53.57[c]
Maternal education (%)				
High school or less	23.67	23.85	15.63	32.14
Associate degree	24.85	23.85	21.88	32.14
Bachelor's degree	21.89	20.18	28.13	21.43
Graduate	29.59	32.11	34.38	14.29

Household income (%)				
< $25,000	30.18	33.03	18.75	32.14
$25,001 – 50,000	16.57	15.60	18.75	17.86
$50,001 – 75,000	14.20	15.60	18.75	3.57
>$75,001	36.05	35.78	43.75	46.43

Data expressed as mean ±standard error or as indicated, [a] $p < 0.001$ corresponds to NW or OB. [b] $p < 0.001$ corresponds to OW versus OB. [c] $p < 0.0001$ corresponds to <30 minutes versus > 60 minutes and 30-60 minutes versus > 60 minutes in the obese group. [d] $p < 0.02$ corresponds to before 6:00 PM versus after 7:00 PM in obese group. BMI = body mass index, NW = normal weight, OB = obese, OW = overweight.

Table 2. Comparison of bedtime, wake-up time, and sleep duration across the sleep behavior categories.

Characteristic	EE (n = 30)	EL (n = 69)	LE (n = 30)	LL (n = 40)
Bedtime	7:44 PM ± 27 [b c d]	8:01 PM ± 19 [a c d]	8:48 PM ± 9 [a b]	8:48 PM ± 10 [a b]
Wake-up time	5:40 AM ± 11 [b d]	6:24 AM ± 18 [a c d]	5:42 AM ± 9 [b d]	6:45 AM ± 18 [a b c]
Sleep duration	9:56 ± 31[b c]	10:23 ± 23 [a c d]	8:54 ± 12 [a b d]	9:57 ± 22 [b c]

Data expressed as mean ± standard deviation. Bedtime and wake-up time are clock time ± minutes. Sleep duration is hours: minutes ± minutes slept in a 24- hour period. [a] $p < 0.0001$ verse EE. [b] $p < 0.0001$ versus EL. [c] $p < 0.0001$ versus LE. [d] $p < 0.0001$ versus LL. EE = early bed/early wake-up, EL = early bed/late wake-up, LE = late bed/early wake-up, LL = late bed/early wake-up time.

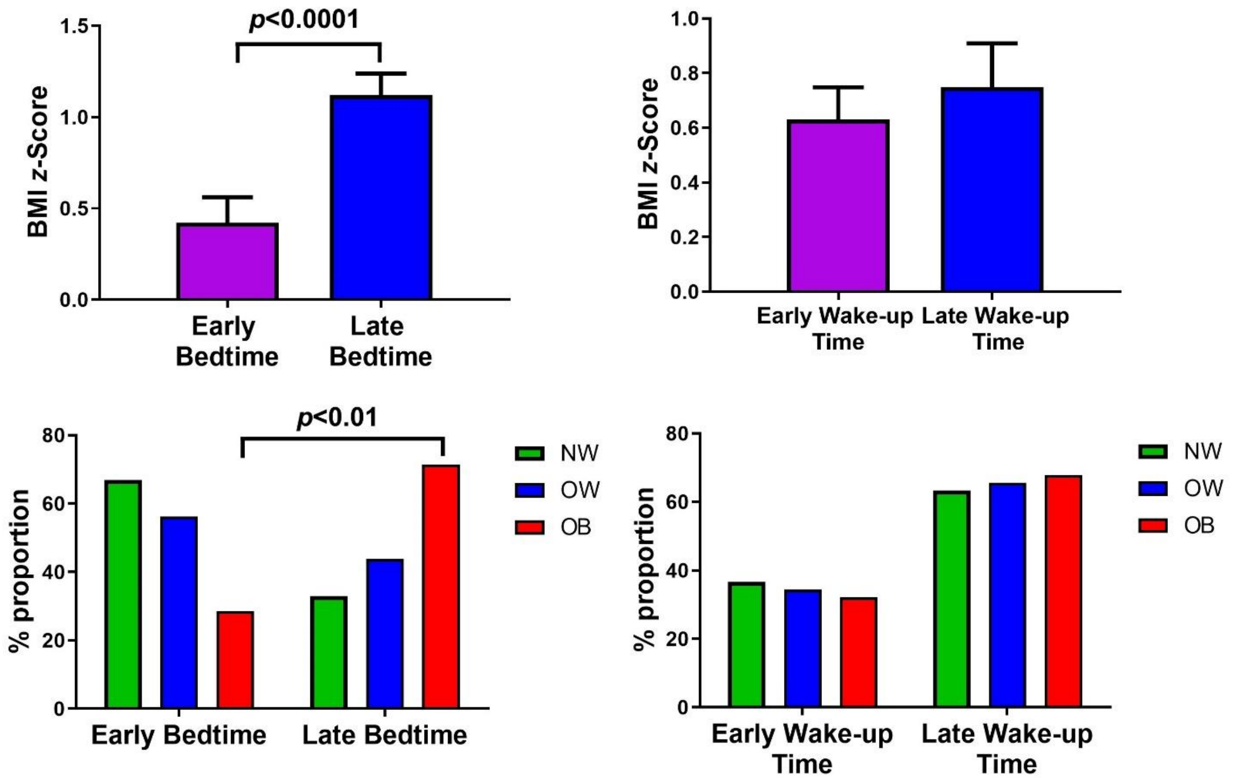

Figure 1—The relationship between bedtime and wake-up time with obesity.

(A) Early and late bedtime versus BMI z-score. (B) Percentage of normal weight, overweight, and obese participants in early and late bedtime category. (C) Early and late wake-up time versus BMI z-score. (D) Percentage of normal weight, overweight and obese participants in early and late wake-up time category. BMI = body mass index, NW = normal weight, OB = obese, OW = overweight.

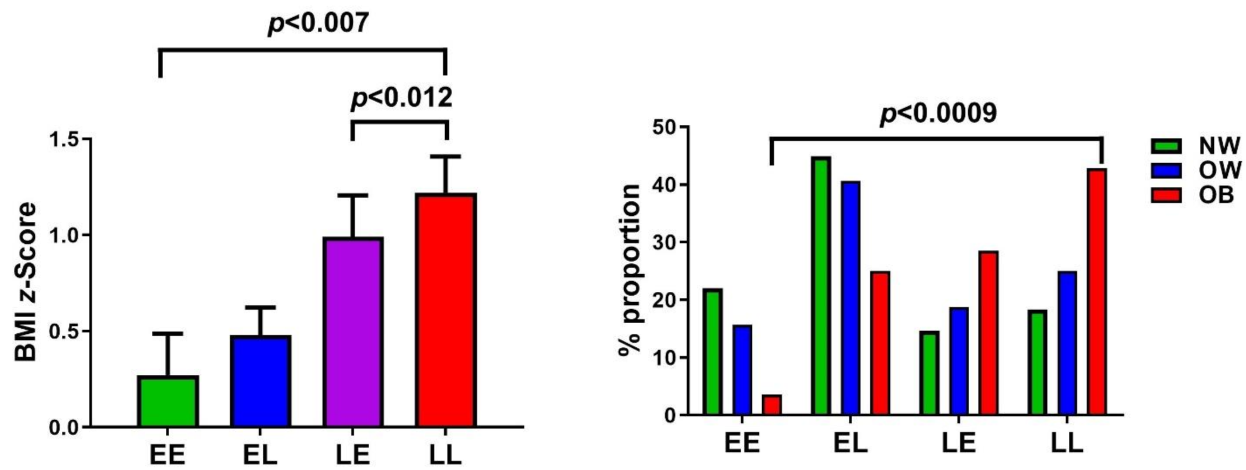

Figure 2—The relationship between sleep behavior categories and obesity. (A) Sleep categories versus BMI z-score. (B) Percentage of normal weight, overweight, and obese participants in four sleep categories. BMI = body mass index.

Table 3. Association between sleep behavior categories and BMI z-score.

	Unadjusted					**Adjusted**				
Sleep				**95% CL**					**95% CI**	
Category	**β**	**OR**	**P**	**LB**	**UB**	**β**	**OR**	**P**	**LB**	**UB**
EL	0.149	1.16	0.422	0.807	1.67	0.090	1.09	0.65	0.739	1.62
LE	0.513	1.67	0.023	1.073	2.60	0.222	1.25	0.41	0.734	2.12
LL	0.689	1.99	0.002	1.299	3.05	0.539	1.71	0.03	1.053	2.79

Multinomial logistic regression was used to analyze the data, with EE group as reference category. The results were adjusted for age, sex, television exposure time and dinner time. CI = confidence interval, EE = early bed/early wake-up, EL = early bed/late wake-up, LB = lower bound, LE = late bed/early wake-up, LL = late bed/early wake-up time, OR = odds ratio, UB = upper bound.

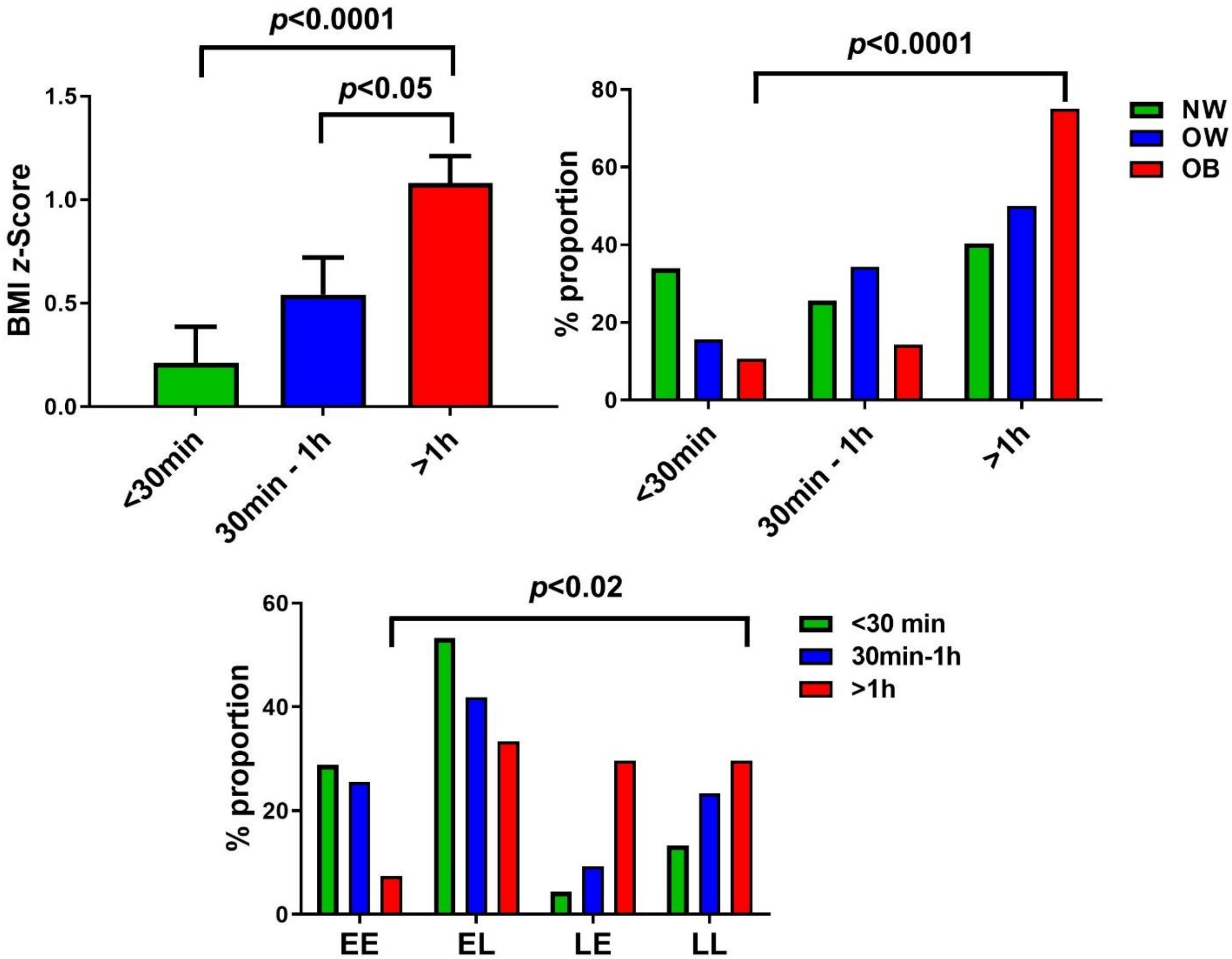

Figure 3—The relationship between television exposure time and obesity. (A) BMI z-score vs television exposure time. (B) Percentage of normal weight, overweight, and obese participants in different television exposure time categories. (C) Percentage of participants in EE, EL, LE, LL groups across the television exposure time categories. BMI = body mass index, EE = early bed/early wake-up, EL = early bed/late wake-up, LE = late bed/ early wake-up, LL = late bed/early wake-up time.

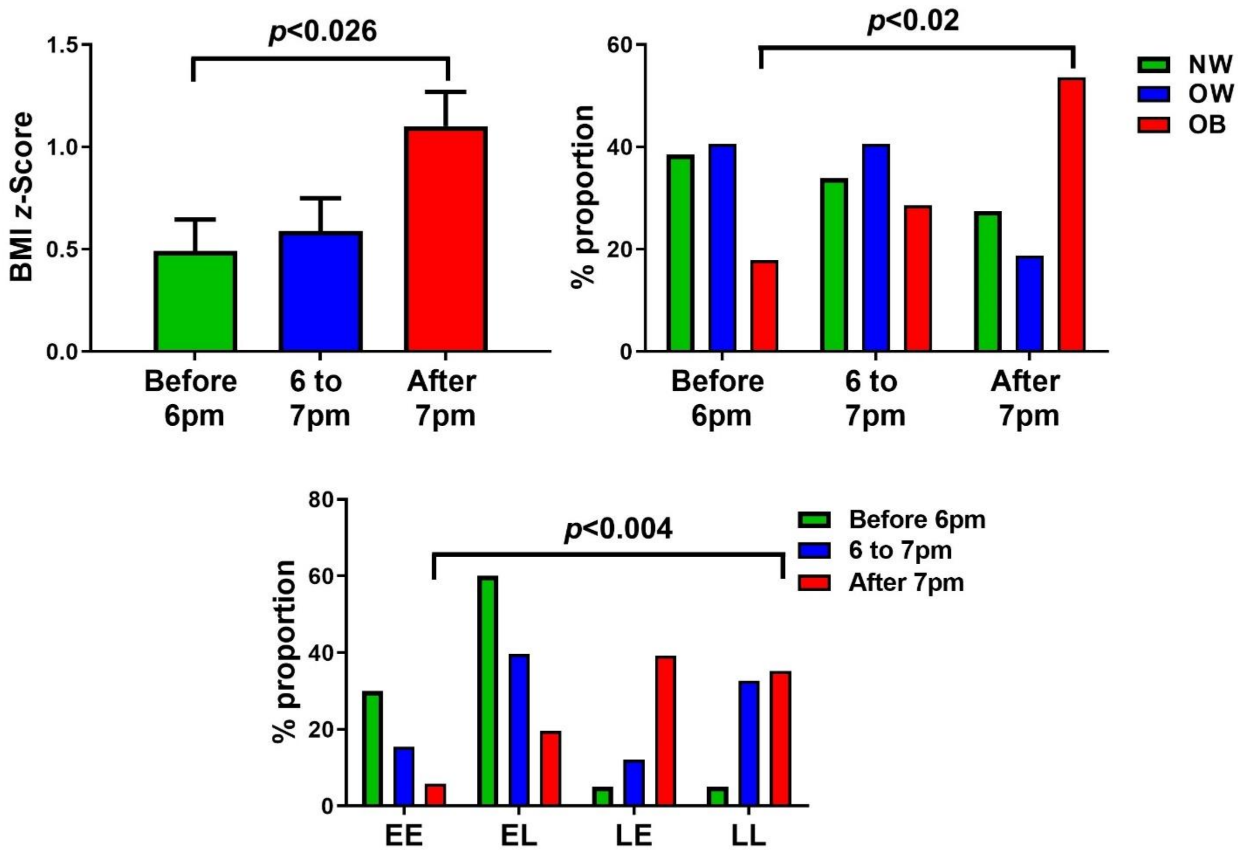

Figure 4—The relationship between dinnertime and obesity. (A) BMI z-score vs different dinnertimes. (B) Percentage of normal weight, overweight, and obese participants in different dinnertimes. (C) Percentage of participants in EE, EL, LE, LL groups across three different dinnertimes. BMI = body mass index, EE = early bed/early wake-up, EL = early bed/late wake-up, LE = late bed/early wake-up, LL = late bed/early wake-up time.

Also, the relationship of dinnertime with BMI z-score and sleep timing behavior was analyzed. The participants were separated into three groups based on dinnertime before 6:00 PM, between 6:00 to 7:00 PM, and after 7:00 PM. BMI z-score is significantly higher in participants with dinnertime at or after 7:00 PM ($p < .026$), compared to participants with earlier dinner-time, as shown in Figure 4A. Approximately 54% of participants with dinnertime after 7:00 PM are obese, compared to 18% with dinnertime before 6:00 PM who are obese ($p < .02$) as shown in Figure 4B. Figure 4C shows the relationship between sleep timing behavior categories and the dinnertime of the participants. The proportion of dinnertime with the sleep behavior categories shows that 35% of participants in the LL category and only 6% in the EE group have dinner after 7:00 PM ($p < .004$). The participants with late bedtime are more likely to have late dinnertime. The results suggest that longer television exposure time and late dinnertime are related to increased BMI and a late bedtime.

3.5 Discussions

In the current study, we found a significant increase in the BMI of children with late bedtime/late wake-up time compared to early bedtime/early wake-up, despite having the same sleep duration. The CDC called insufficient sleep a public health epidemic. Several studies have reported that short sleep duration increases the risk of obesity [23-27], diabetes [28], and reduced quality of life [29]. Short sleep duration has been shown to have negative effects on endocrine functions such as increasing the secretion of cortisol and ghrelin and reducing leptin secretion thereby affecting glucose tolerance [30]. In addition, lack of sleep has been associated with anxiety, depression [31], inability to focus [32] and to remember information [31] leading to poor academic performance, and a greater likelihood of injuries and accidents [33]. In this study, children with late bedtime/early wake-up time (LE group) had the shortest sleep duration compared to all other sleeping patterns. We may expect that this group will have the most significant BMI, but we found a significantly high BMI with late bedtime/late wake-up time (LL group), and the lowest BMI in early bedtime/early wake-up time (EE group), whereas both groups have the same sleep duration.

This high BMI in late bedtime/late wake-up time is mainly associated with the late bedtime and not the late wake-up time, as we did not find a significant difference in the BMI between early and late wake-up time. The results suggest that the higher BMI is not dependent on the sleep duration but on bedtime. A similar study has shown that preschool children with an early bedtime were half as likely to be obese compared to children with late bedtimes [34]. The late bedtime might not only be associated with the higher BMI, so we explored the relationship of the sleep timing pattern with television exposure time and the dinnertime of children. Children with late bedtime may tend to have a late dinner and watch television. In this study, we also found that the longer television exposure corresponds to a higher BMI z-score of children. Previous studies have shown that children exposed to longer television viewing time are more likely to become obese [35,36]. It has been demonstrated that children who have a television in their bedroom were more likely to be overweight compared to those who do not have a television in their bedrooms [37]. Television watching is one of the sedentary behaviors that induces a low metabolic rate and prevents other physical activities that consume the body's higher energy levels [38]. A study with Japanese preschool children has shown that those participants with shorter screen exposure, longer sleep duration, and an early dinnertime had the lowest percentage of overweight/obesity [39]. Late dinnertime has proved to be associated with higher BMI in adults [40].

Our results also suggest that children having dinner after 7:00 PM have a higher BMI z-score. Of the children who had a late bedtime (8:48 PM), approximately 60% of them watched television for longer than 1 hour, and 75% had dinner after 7:00 PM. The higher BMI z-score is not only in children with late bedtime but also with more prolonged television exposure and late dinnertime.

The limitations of this study are that the results are based on the small number of participants from the wide age range, low proportions of participants with obesity, and these results needed to be confirmed with a more extensive cohort study. The participants generally are highly educated and have moderate to high income. Other factors that could influence childhood obesity, such as socioeconomic status, food quality, parental influences, and physical activity, are not included. Also, bedtime is reported by the parents and there can be a difference in the time of a child going to bed and actual sleeping.

In this study, we explored the relationship of obesity in children with the sleep timing pattern, television exposure time, and dinnertime. We observed that children with late bedtime/ late wake-up times are more likely to have obesity than children with early bedtime/early wake-up time, despite having the same sleep duration. The higher BMI in children with late bedtime/late wake-up time seems to be associated with late bedtime and not wake-up time. Bedtime, rather than sleep duration, is an essential factor for obesity in children. The higher BMI is also observed in children with more television exposure and late dinnertime.

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Chapter 4: Parental Feeding Practices in Relation to Maternal Education and Childhood Obesity

4.1 Abstract

Parental beliefs, attitudes, and feeding practices play a vital role in childhood obesity. This study aimed to assess parental perceptions, concerns about weight, feeding practices using the Child Feeding Questionnaire (CFQ), and its association with body mass index (BMI) and maternal education in elementary school children. Participants aged 6–10 years (n = 169) were recruited, and anthropometric measurements were obtained. Pearson's correlation and hierarchical linear regression analysis were used to examine the association between BMI z-score and the seven factors of the CFQ. The BMI z-score was significantly associated with parental perceived child weight and concern about child weight. The BMI z-score had a significant negative association with parents pressuring children to eat.

Parents of obese children reported significantly higher ($p < 0.001$) levels of perceived child weight ($\beta = 0.312$) and concern ($\beta = 0.320$) about their child's weight compared to the normal weight and overweight groups. Parents of overweight children showed considerably less ($\beta = -0.224$; $p < 0.005$) pressuring towards their children to eat as compared to parents of normal weight children. Additionally, we found that the parental feeding practice (pressure to eat) was only dependent upon maternal education. The path analysis indicates that maternal education has a moderating effect on BMI z-score and pressure to eat is related to BMI z-score through maternal education. The findings demonstrate the association between the parents' perceptions, concerns, and pressure to eat with BMI z-score of elementary school-aged children. Only the parental feeding practice pressure to eat was dependent upon maternal education.

Keywords: parental feeding practices; child weight status; obesity; parental perceptions

4.2 Introduction

Although childhood obesity has received significant attention over the past few decades, it remains a major public health concern [1]. In the United States, childhood obesity has tripled in the past decade with current estimates showing approximately 13.7 million children and adolescents obese [2]. In Alabama, more than 36% of children are overweight and obese, and is the 5th highest ranked state in obesity [3]. Obesity is typically characterized by an increase in body fat mass [4]. The common causes of childhood obesity include diet, behavioral, and genetic factors [5]. Chronic diseases such as type 2 diabetes mellitus, hypertension, and hypercholesterolemia have been established to be associated with obesity [6]. The persistence of childhood obesity into adulthood and its connection with morbidity is a major problem [7]. Additionally, childhood obesity is associated with several short and long-term health adverse effects, therefore, it is crucial to identify early and address it with efficient methods. Some of the adverse health effects includes metabolic disease [8], cardiovascular related disease [9–12], retinal and renal problems [13,14], and nonalcoholic fatty liver disease [15,16]. The transition of the world's nutritional changes begun with a high intake of processed food, sugary food, beverages, artificial juice, and drinks [17].

Children learn about food context in their earlier periods from their families [18]. Children's first nutritional educators are their parents and channelize their food context and eating behavior. Parental beliefs and feeding practices play a very critical role in shaping the eating behaviors of children [18]. The eating habits and physical activity of children are influenced mainly by parental beliefs and perceptions [18]. Furthermore, parents' educational level has been found to affect their ability to process health information, leading to improved health-related decisions. The new health information drives their inspiration to adopt a healthy lifestyle as role models for their children [19,20]. Though maternal education level has been established to play a role in feeding practices of their children, not many studies have been conducted to examine the influence of maternal education on parents' perceptions, concerns, and feeding practices regarding child weight. Therefore, this study will fill the gap in information to examine the relationship between parental perception, feeding practices with children's BMI, and maternal education using the Child Feeding Questionnaire (CFQ).

The CFQ is a self-reported instrument often used to assess parental feeding attitudes, beliefs, and susceptibility to obesity [21,22]. The association between parental feeding practice and obesity is not consistent across studies. Research conducted from the UK and Australia did not show the association between parental restriction and child weight [23–25]. The longitudinal study showed no correlation between pressure to eat and childhood obesity measures [25,26]. A further few studies conducted in children showed parental feeding practice varied across their ethnicity and socioeconomic status [24]. In another study, less restrictive feeding practice was positively associated with child weight status in Swedish children [27]. The systemic reviews showed the investigation of maternal feeding practice concerning children's dietary intake, and BMI has focused on feeding practice [28–30]. The present study hypothesizes the existence of association between the parents' perceptions, concerns, and feeding practices with children's BMI z-score and maternal education in elementary school-aged children. The age groups (6 to 10 years) of the study participants reflect when the child matures and starts to eat outside the house environment, though they still are affected by parents' control in their feeding practice and selection of food [31].

In the present study we asked two questions: first, to what extent are parents' perceptions, concerns, and feeding practices related with the obesity of children? Second, are any of the associated factors correlated with maternal education? For this we investigated the association between BMI z-score and the seven factors of the CFQ. In addition, we examined the influence of maternal education on the factors that were significantly associated with BMI z-score.

4.3 Materials and Methods

4.3.1Participants and Data Collections

Participants were 169 children aged 6-10 years from the Lee and Macon counties in Alabama. A study flyer was designed and distributed in and around the area. Participants were recruited at home schools, after-school programs, through friends, and through participant referrals. Parents interested in participating in the study reached out either by email or phone. Participants younger than 6 years and older than 10 years, with medical conditions such as diabetes, cardiovascular disease, or sleep apnea and those taking any medications were excluded from the study based on phone interview. Parents came with their children to Auburn University for anthropometric measurements and to complete questionnaires. In addition, the same participants were used to determine the relationship between obesity and sleep timing behavior [32]. Maternal education was collected and categorized as high school or less, associate degree, Bachelor’s degree, or graduate degree. Written consent was obtained from the parents and participants. This study was approved by the Auburn University Institutional Review Board (Protocol # 17-364 MR 1709). The appropriate sample size analyses were performed using G*Power 3.1.9.4. One way-Analysis of Variance (ANOVA) for three groups showed greater than power $(1-\beta) = 0.80$ with $\alpha = 0.05$ to detect 0.25 change (effect size) in the sample groups of minimum 159 participants.

4.3.2 Anthropometric Measurements

The bodyweight of the children was measured without shoes or heavy clothing to the nearest 0.1 kg. The children's height was measured to the nearest 0.1 cm on a calibrated scale attached to a stadiometer. BMI was defined based upon the ratio of weight to height (squared) of the participants. The children were classified according to BMI percentile charts for age and sex from the Center for Disease Control and Prevention [2] as underweight (BMI < 5th), normal weight (BMI ≥ 5th to < 85th), overweight (BMI ≥ 85th to < 95th), and obese (BMI ≥ 95th) (CDC, 2015). Based on the WHO growth reference 2007 data, BMI z-score was calculated using SPSS macro adjusting for age and sex [33].

4.3.3 Description of Factors in the Child Feeding Questionnaire (CFQ)

The CFQ is a tool developed to measure parents' perceptions, concerns about child weight status, child-feeding attitudes, and practices [34]. It consists of 7 factors and 30 subscales. There are four factors to measure parents' perception and concern about weight and three factors to determine the parents' attitudes and feeding practices. The first factor in measuring parents' perception and concern about weight is perceived responsibility [26], which consists of 3 subscales measuring parents' perceived responsibility in feeding their child. The second factor is perceived parent weight (PPW), composed of 4 subscales that assess the history of the parents' perceptions of their weight status. The third factor is perceived child weight (PCW), which measures parents' perceptions of the weight status of their children from the time of birth. The fourth factor is the parental concern (CN), consisting of 3 subscales and assessing parental concerns about their child's risk of being overweight. The remaining three factors measure parents' attitudes and feeding practices. The first factor of feeding practices includes restriction (RST) which measures the extent to which parents limit their child's access to food. The second factor is pressure to eat (PE) which assesses parents' tendency to pressure their children to eat more food. The final factor is monitoring (MN) which measures the extent to which parents supervise their child's eating. The abbreviations for the factors used in this manuscript are consistent with the original abbreviations presented in previous studies [27,34] with minor modifications.

4.3.4 Statistical Analysis

The data were analyzed using Statistical Package for Social Sciences (SPSS) version 25.0 for Windows, IBM, and Armonk, NY, USA. Descriptive statistics are expressed as the mean ± standard error or mean ± standard deviation (SD). $p < 0.05$ is considered as statistically significant. Analysis of variance (ANOVA) was used to compare the mean difference for participant's age, gender, maternal education, BMI, and BMI z-score. The distribution of predictive factors was evaluated for multicollinearity and normality (skewness). Log-transformation was done for more skewed data of child feeding questionnaire factors and used for hierarchical regression analysis. Cronbach's alpha was evaluated for items on each of the seven factors to assess internal consistency. Pearson's correlation was used to determine the relationships between the mean item scores for each of the seven factors in the CFQ and BMI z-score.

To determine which group of factors in the CFQ would predict BMI z-score of children, the following variables were accounted for: gender, age, and maternal education. We ran a hierarchical linear regression with BMI z-score as the dependent variable. All seven factors of the CFQ were the predictors and the potential confounding variables. Based on the maternal education status, participants' mean difference in the significant CFQ factors was analyzed by one-way ANOVA. A path analysis was conducted to identify the relation between the significant CFQ factors and BMI z-score. Furthermore, the direct and indirect effects were evaluated using maternal education as the mediating variable in the model. According to Kheirollahpour and Shohaimi [35], two paths are considered for testing the direct and indirect relationship in the model. One-way ANOVA was used to examine the mean difference for significant factors from the regression analysis (perceived child weight, parental concern, pressure to eat). Tukey's test was used for post-hoc comparison between groups.

4.4 Results

The descriptive characteristics of the study population are presented in Table 1. Sixty-four and a half percent (n = 109) of participants were normal weight (NW), 18.9% (n = 32) were overweight (OW), and 16.6% (n = 28) were obese (OB). The ages of participants ranged from 6 to 10 years with a mean age of 8.42 years for all the participants. There were no significant differences observed in age, gender, or maternal education. However, there was a significant difference in BMI z-score of the OW and the OB group compared to NW participants. The average score for the subscales for each factor in CFQ was calculated. Cronbach alpha for the CFQ factors was calculated for internal consistency and it ranged from 0.66 to 0.94, as presented in Table 2. The minimum criteria of Cronbach alpha for acceptable reliability were above 0.60 [36].

Table 1. Descriptive characteristics of study population.

	NW	OW	OB	*p* value
All	109 (64.5%)	32 (18.9%)	28 (16.6%)	
Age (y)	8.37 ± 1.44	8.28 ± 1.29	8.77 ± 1.46	0.349
Gender (%)				
Male	50.46%	50.0%	42.86%	
Female	49.54%	50.0%	57.14%	
Maternal Education (%)				
High School or less	23.85%	15.63%	32.14%	
Associate Degree	23.85%	21.88%	32.14%	
Bachelor's Degree	20.18%	28.13%	21.43%	
Graduate	32.11%	34.38%	14.29%	
BMI z-score	-0.02 ± 0.82	1.56 ± 0.26	2.56 ± 0.37	$p < 0.001$

NW = Normal Weight; OW = Overweight and OB = Obese; BMI = Body mass index. The values are represented as mean ± SD. Part of the data presented in the table was used in our previously published article [32].

Table 2. Cronbach Alpha of factors of the CFQ.

Factor	Mean ± SD	Cronbach Alpha
PR	3.41 ± 0.70	0.89
PPW	2.23 ± 0.41	0.66
PCW	1.97 ± 0.31	0.75
CN	0.94 ± 1.19	0.87
RST	2.59 ± 0.97	0.83
PE	1.69 ± 1.18	0.80
MN	2.89 ± 1.12	0.94

Perceived Responsibility (PR), Perceived Parent Weight (PPW), Perceived Child Weight (PCW), Parental Concern about Child Weight (CN), Restriction (RST), Pressure to Eat (PE), and Monitoring (MN).

The bivariate correlation between the CFQ factors and BMI z-score is shown in Table 3. A significant positive correlation was observed between perceived child weight (r = 0.399), parental concern (r = 0.399), and BMI z-score. The strongest correlation between factors is shown in restriction and pressure to eat (r = 0.403); monitoring (r = 0.322), parental concern and restriction (r = 0.345), monitoring (r = 0.341), perceived child weight (r = 0.218), and restriction (r = 0.238) showed a positive correlation with perceived responsibility. Perceived child weight also showed correlation with monitoring (r = 0.321), parental concern (r = 0.302), and restriction (r = 0.171). Similarly, the magnitude of coefficient in pressure to eat and monitoring (r = 0.262), perceived parent weight, and concern (r = 0.154) were reported. A significant negative correlation was observed between pressure to eat (r = −0.177) and BMI z-score.

Table 3. Pearson's correlations between CFQ factors and BMI z-score.

	BMI z-score	PR	PPW	PCW	CN	RST	PE	MN
BMI z-score	1.000							
PR	-0.031	1.000						
PPW	0.122	0.008	1.000					
PCW	0.399**	0.218**	0.062	1.000				
CN	0.399**	0.115	0.154*	0.302**	1.000			
RST	0.052	0.238**	0.068	0.171*	0.345**	1.000		
PE	-0.177*	0.129	-0.073	-0.065	0.080	0.403**	1.000	
MN	0.038	0.341**	-0.62	0.321**	0.116	0.322**	0.262**	1.000

Body mass index (BMI), Perceived Responsibility (PR), Perceived Parent Weight (PPW), Perceived Child Weight (PCW), Parental Concern about Child Weight (CN), Restriction (RST), Pressure to Eat (PE), and Monitoring (MN). * Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

The hierarchical linear regression model was used to examine the association between BMI z-score (dependent variable) and the seven factors of the CFQ (independent variable). Gender, age of participants, and maternal education were entered into the model in the first step to adjust the potential confounding variables, followed by entering each of the predictors separately. This was done to help us observe the predictive power of each of the predictors as presented in the R square change seen in the table. The grouping of the subscales was done by averaging the subscales of each factor according to Birch et al. 2001 and Nowicka et al. 2015 [27,34]. The overall equation was statistically significant ($F_{10,158} = 8.665$, $p < 0.001$). About 34% of the variance in the child BMI z-score was explained by the child feeding questionnaire

($R^2 = 0.341$, Adj. $R^2 = 0.299$). Perceived child weight (B = 7.644, β = 0.312, t = 4.275, $p < 0.001$), concern about child weight (B = 1.691, β = 0.320, t = 4.398, $p < 0.001$), and parents pressuring children to eat (B = −1.342, β = −0.224, t = −2.864, p = 0.005) were significant factors in predicting child weight status. The other four factors were not statistically significant, as shown in Table 4. The findings indicate that BMI z-score was positively associated with perceived child weight and parental concern and negatively associated with pressure to eat.

Table 4. Hierarchical linear regression analyses for BMI z-scores on CFQ factors.

CFQ Factors	B-Value	Change in R2	β (95% CI min, max)	*p* Value
PR	-1.562	0.001	-0.108 (-1.669, 1.453)	0.130
PPW	1.105	0.016	0.050 (1.155, -1.055)	0.454
PCW	7.644	0.165	0.312 (7.956, -7.332)	**< 0.001**
CN	1.691	0.069	0.320 (2.009, -1.369)	**< 0.001**
RST	-0.531	0.014	-0.063 (-0.595, 0.469)	0.427
PE	-1.342	0.034	-0.224 (-1.564, 1.116)	**0.005**
MN	0.164	0.000	0.023 (0.187, -0.141)	0.767

The results were adjusted for the child's gender, age, and maternal education. Perceived Responsibility (PR), Perceived Parent Weight (PPW), Perceived Child Weight (PCW), Parental Concern about Child Weight (CN), Restriction (RST), Pressure to Eat (PE), Monitoring (MN). Statistically significant factors were represented in bold.

Since perceived child weight, parental concern, and pressure to eat were significantly associated with BMI z-score, we further compared the means of these significant predictors with the NW, OW, and OB groups using one-way ANOVA. Parents of children in the OB category reported significantly higher ($p < 0.0001$) levels of perceived child weight and parental concern compared to the NW and OW group. Parents of OW children showed considerably less ($p < 0.05$) pressuring their children to eat as compared to NW (Figure 1).

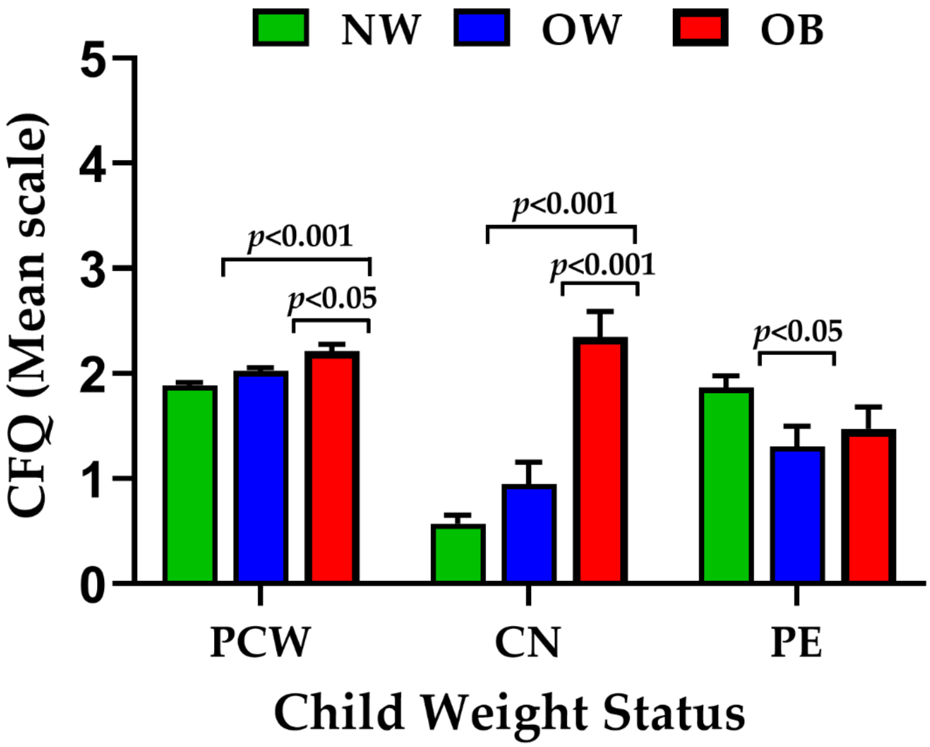

Figure 1. Bar graph showing the relation between the perceived child weight (PCW), parental (CN), and pressure to eat (PE) factors with the NW, OW, and OB participants. The values in the graph are represented as mean ± SEM.

The relationship of these significant factors, perceived child weight, parental concern, and pressure to eat, with maternal education was determined. The one-way ANOVA result (Table 5) indicated that the children of mothers with high school or less education showed significantly high pressure to eat compared to other maternal education categories.

Table 5. One-way ANOVA of CFQ factors score with respect to the maternal education and weight categories.

Maternal Education	PCW	CN	PE
High School or less	1.94 (0.19)	0.87 (1.03)	2.56 (1.18)
Associate Degree	1.94 (0.37)	1.35 (1.38)	1.88 (1.18) *
Bachelor's Degree	2.09 (0.36)	0.74 (1.10)	1.09 (0.96) **
Graduate	1.92 (0.30)	0.79 (1.16)	1.29 (0.88) **

Data are expressed as mean (SD); * $p < 0.05$ and ** $p < 0.0001$ are considered significant compared to the High School or less group. Perceived Child Weight (PCW), Parental Concern about Child Weight (CN), Pressure to Eat (PE).

These significant factors were further confirmed by the path model which provided an acceptable fit to the data ($\chi 2 = 31.786$, df = 12, p = 0.001, CFI = 0.812, RMSEA = 0.09) [37]. As presented in Figure 2, pressure to eat had a significant negative relation with maternal education ($B = -1.53$, $p < 0.001$) and BMI z-score ($B = -2.15$, $p < 0.001$). Maternal education had a negative relation with child BMI z-score ($B = -0.23$, $p = 0.002$). Parental concern ($B = 1.61$, $p < 0.001$) and perceived child weight ($B = 7.11$, $p < 0.001$) had a positive relation with child BMI z-score and no significant relation with maternal education. In the model, the largest effect was observed from PE to maternal education.

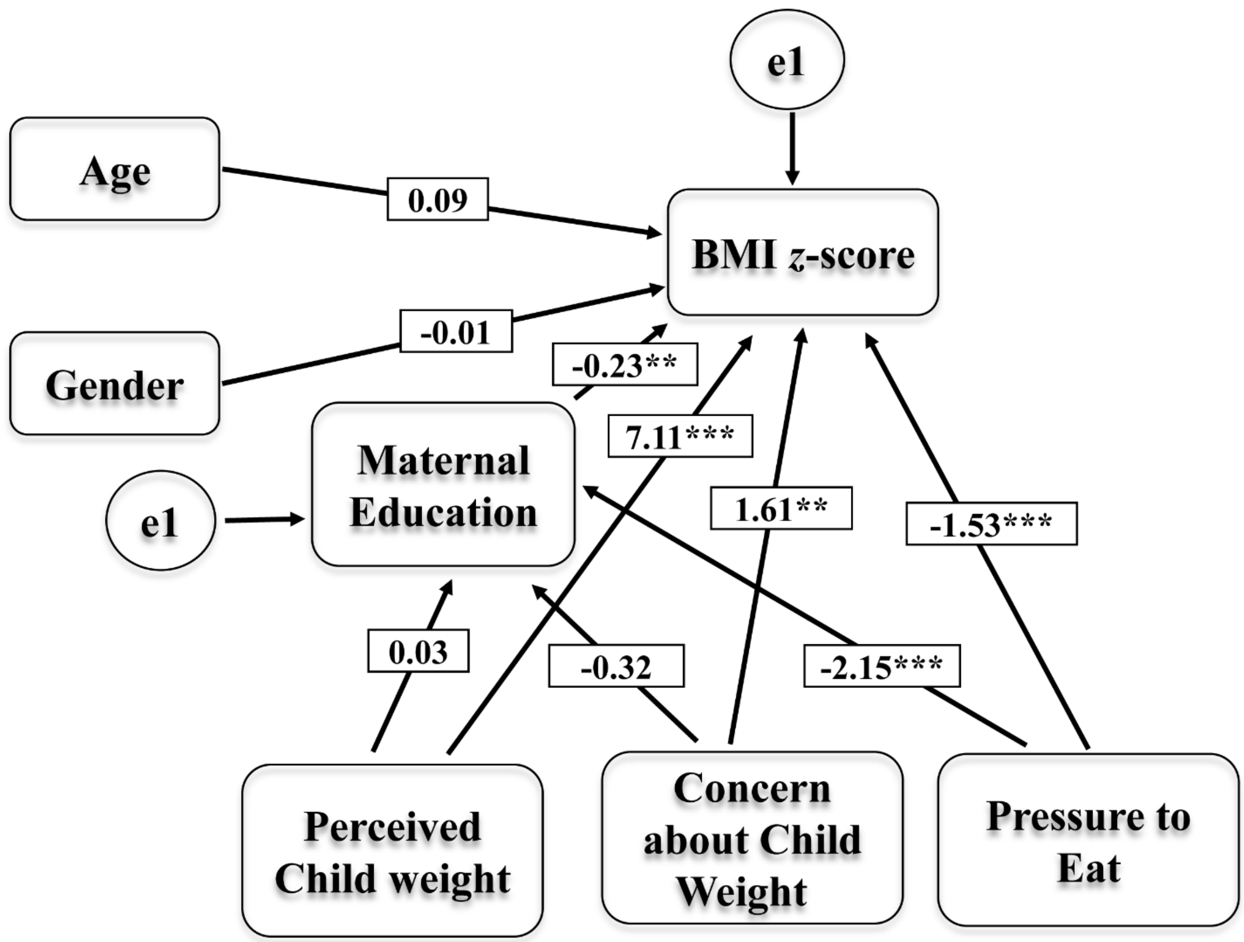

Figure 2. Path model showing the direct and indirect relation of the Perceived Child Weight, Parental Concern, and Pressure to Eat factors with BMI z-score through maternal education. Significant levels are $^{**}p < 0.01$ and $^{***}\ p < 0.0001$.

4.5 Discussion

This study uses the CFQ as a tool to assess the relationship between the parent's perception, concerns, and feeding practices with the children's BMI z-score and maternal education. The internal reliability determined by Cronbach's alpha was acceptable to excellent for the factors used. Three out of the seven factors (PCW, CN, PE) of the CFQ were found to be significant predictors of child BMI z-score using Pearson's correlation analysis. The perceived child weight and parental concern measure the parental perceptions and concerns about child weight. The perceived child weight and parental concern were positive predictors of child BMI z-score. Pressure to eat, measuring the parental feeding practices, was negatively influenced by the BMI z-scores, as reported by several other studies [38–41]. We found their child is obese, which is like other studies [42–44]. Furthermore, parents place less pressure on their overweight and obese children to eat compared to normal weight children [24,27,38]. The parental beliefs, attitudes, and feeding practices can be altered to reduce obesity [41]. However, in several studies, there are discrepancies in the relationship between parental feeding practices and obesity. Other studies found restriction to be a significant predictor of child BMI z-score. Restriction was not a significant predictor in our study, and this may be due to the age difference of the participants [27,38]. However, no relationship is found between parental restriction and obesity in studies conducted in Australia and the United Kingdom [23,25,45]. Similarly, the pressure to eat is found not to be associated with obesity in longitudinal studies [25,26]. In agreement with our results, the correlation analysis found that BMI z-score was negatively correlated with pressure to eat among children aged 2–4 years [46]. Populations from low-income are known to be affected more by obesity [47,48]. Education may offer mothers with the awareness of the importance of nutrition in health, knowledge of children's weight status as a risk factor for health problems in future and maintains a good feeding practice to help in keeping a healthy weight [49]. The relationship between socio-economic status and parental feeding practices has been studied, but the results are not consistent [25,50,51]. Hence, the impact of maternal education was evaluated on the factors that were significantly associated with obesity: perceived child weight, parental concern, and pressure to eat. The parental feeding practice pressure to eat was only dependent upon maternal education. Mothers with a high school or less education pressurized their children to eat more when compared to mothers with higher education levels. This was confirmed with the path model showing that perceived child weight, parental concern, and pressure to eat were significantly associated with BMI z-score, but PE was only significantly related to maternal education. The study conducted by Nowicka et al 2014, describes that child BMI had direct relation to restriction, whereas pressure to eat was influenced by parental education [27]. The path model indicated that maternal education had a moderating and a direct effect on BMI *z*-score. Pressure to eat is related to BMI *z*-score and to a certain extent through maternal education. Maternal education may play a vital important role in the parental feeding practices and BMI of children. A study carried out by Cardel et al. (2012) found that socioeconomic status was negatively associated with restriction and pressure to eat [24], but our results showed maternal education was inversely related only with pressure to eat. The findings of this current study should be interpreted under this limitation. Although participants were recruited from Lee and Macon counties in Alabama, the sample cannot be considered a representation of Alabama children. The results are based upon a relatively small number of participants and a low percentage of obese participants. Another limitation of this study is that it is a cross-sectional study, but not a longitudinal study. The information obtained from these studies may not be sufficient to understand the disease trend. The cross-sectional study design provides us information about the prevalence of disease outcomes to design the cohort or longitudinal studies and gives the estimates to study the association of this study.

4.6 Conclusion

This study has furthered scientific understanding of the relation between parental perceptions, concerns, and feeding practices with the child's obesity and maternal education. Our findings show that perceived child weight and parental concern were positively associated with BMI z-score. And the pressure to eat was negatively associated with BMI z-score of elementary school-aged children. Out of these factors, the parental feeding practice pressure to eat was only dependent upon maternal education.

4.7 References

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Chapter 5: Eating Behaviors in Relation to Child Weight Status and Maternal Education

5.1 Abstract

The eating behavior of children is important to maintain a healthy weight. This current study explored the differences in children's eating behaviors and their relation to weight status and maternal education level, using the child eating behavior questionnaire (CEBQ). Methods: The study recruited 169 participants aged between six and ten years. Multinomial logistic regression was conducted to examine the association between the CEBQ factors and children's body weight status. The association between the CEBQ scores and maternal educational levels was examined using a one-way analysis of variance (ANOVA). Results: The multinomial logistic regression findings indicate that children in the obese group exhibited a significant increase in food responsiveness, enjoyment of food, emotional overeating, and a decrease in satiety responsiveness compared to normal weight children. The one-way ANOVA showed a significant difference in subscales under the food approach (food responsiveness, desire to drink, emotional overeating) and food avoidance (satiety responsiveness) based upon the child's weight status. The three subscales under the food approach category were significantly dependent upon the maternal education but did not have a significant association with food avoidance. The results suggest that the increase in food responsiveness and emotional overeating in obese children is influenced by maternal education.

Keywords: child eating behavior; childhood obesity; maternal education; food avoidance; food approach

5.2 Introduction

Despite researchers' significant efforts to combat obesity, it remains a critical health concern worldwide as its prevalence keeps rising steadily [1]. Obesity is a metabolic disorder due to the accumulation of body fat, and it is usually measured using the World Health Organization (WHO) classification of body mass index (BMI). BMI is defined as the ratio of body weight in kilograms (kg) to height in meter squared (m^2). For instance, an adult with a BMI of <18.5 kg/m^2 is classified as underweight, 18.5–24.9 kg/m^2 is classified as normal weight, and >30 kg/m^2 is considered obese [2]. Overweight and obesity are considered risk factors for various chronic diseases such as type 2 diabetes, high blood pressure, heart diseases, stroke, and some forms of cancer [3–7]. Obesity is caused by genetic, behavioral, environmental (for example geography, food availability, and transportation), and socioeconomic factors [8].

Around 12.7 million children and adolescents are classified as obese in the United States [9]. Childhood obesity is often persistent into adulthood [10]. Childhood obesity is often defined as BMI ≥95th percentile [11], and one in five children are considered overweight or obese globally [12], which translates to 41 million infants and young children as reported by a WHO 2016 study [2]. It is reported that a child is 10 to 12 times more likely to be obese when they have two parents with obesity compared to having parents with a healthy weight [13,14]. Not only is parental obesity linked to obesity in their children, but it has also been shown to be implicated in the etiology of eating disorders (Eds), including bulimia nervosa [15], binge-eating disorder [16], and anorexia nervosa [17]. Furthermore, studies indicate that children of mothers with overweight and obesity demonstrate higher emotional eating levels than children of healthy weight mothers [18]. Mothers especially assist their children in learning and developing both eating behaviors and food preferences [19]; it has been reported that children varied their food choices depending on whether they were being observed by their parents or not [20]. In several studies, examining the relationship between maternal education and diet in infants and children revealed that higher educational status was related to the extended duration of breastfeeding, enhanced physical growth, higher intakes of micronutrients, fruits, and vegetables, and lower intake of sugary drinks [21–25].

Another study revealed maternal education as a strong determinant for better nutritional intake in primary school children aged 7–10 years [25]. Additionally, it has been suggested that a child's diet and food preferences are typically influenced by food environments, including their parents' eating behaviors [23,26]. This influence is strongest in early childhood, where parents serve as the gatekeepers and role models around food [27,28]. It tackles disordered eating, which is established to be a cause of childhood obesity. It is essential to understand and positively influence the modifiable determinants of healthy eating behaviors in early life [26,29].

Additionally, maternal education is positively associated with healthier diets not only for mothers themselves [23,30–32], but in their young children under 2 years old [32–34] and older as well [23,31,35,36]. Moreover, low maternal education was found to yield a significant risk of early childhood adiposity [37]. Despite research showing the importance of healthy eating behaviors and the influence of maternal education on childhood weight gain, a great number of children in the United States and other countries has been found to keep poor dietary habits into adulthood [38]. The child eating behavior questionnaire (CEBQ) is a thoroughly compiled parent-report psychometric measure of an array of children's appetitive characteristics to test this theory in samples of children [39]. The CEBQ is used to understand the insight into parents' perceptions of their children's eating behaviors [40]. A previous study using the CEBQ examined the association between the scores of the CEBQ and BMI in a sample of Portuguese children. They found that after controlling for gender, age, and socioeconomic status, all the subscales of CEBQ were significantly associated with BMI z-scores [41]. Jansen et al. [42] used one factor of the CEBQ to assess directionality in the relation between fussy eating parents' pressures on children to eat. The CEBQ is widely used to examine differences in children's appetite in relation to their body weight.

However, not much has been done to examine differences in children's eating behaviors in relation to child weight status and maternal level of education. Additionally, given that childhood obesity increases the chances of becoming obese in one's adulthood, the urgent need to understand eating behaviors in children which has been shown to be influenced by maternal education is emphasized [38]. Therefore, in this study, we aimed to examine (1) the association between the CEBQ and child weight status and (2) the differences in child appetite characteristics in relation to children's body weight and maternal education level.

5.3 Materials and Methods

5.3.1 Participants

Participants (n = 169) aged six to ten years (mean 8.42 ± 0.10) were recruited from the Lee and Macon county area in Alabama. The same participants were used in our previously published articles [43,44]. Therefore, the general characteristics of the study population are presented in those articles. Participants were recruited by posting flyers at after-school programs, childcare, Facebook, as well as through a participant's referral. Exclusion criteria included children with significant health disorders such as diabetes, cardiovascular disease, or diagnosed sleep disorder based on a prior phone survey with parents. The parents brought their children to Auburn University to participate in the study. The appropriate sample size was estimated using

G*Power 3.1.9.4 [43]. Written consent was obtained from both parents and children. The Auburn University Institutional Review Board approved the study.

5.3.2 Anthropometric Measures

Anthropometric measurements such as the body weight and height of the participants were measured according to the WHO recommendations. Body weight was recorded with light clothing using a Tanita digital scale (WB-800H plus), and height was measured using a stadiometer attached with a scale. BMI was calculated using the recorded height and weight as per the Centers for Diseases Control and Prevention (CDC) growth chart. The participants were grouped into normal weight (NW), overweight (OW), and obese (OB) based on the BMI percentile charts for age and sex from the CDC [45]. The details of the measurement are given in our previous studies [43,44].

5.3.3 Psychometric Measures

The CEBQ is a 35-item instrument initially designed and validated to measure a range of children's eating behaviors [39]. The instrument is shown to have good internal consistency, test–retest reliability, and stability over time [39,46]. It has been shown to be related to food intake in the behavioral test [47]. The questionnaire includes four subscales that measure food approach, which consist of food responsiveness (FR), enjoyment of food (EF), emotional overeating (EOE), and desire to drink (DD). It also includes four other subscales that measure food-avoidant-type responses, which include satiety responsiveness (SR), slowness in eating (SE), emotional undereating (EUE), and food fussiness (FF). In a validation study by Wardle et al. [39], SR and SE were found to load onto the same factor, so they have been combined to form a single scale. Parents on behalf of the participants completed the CEBQ. They were provided with options to provide response between “never” and “always” on a 0–4 Likert-type scale. Scale scores were calculated if at least more 75% of the items were completed [42], and subscales of each factor were averaged and used for analysis.

5.3.4 Statistical Analysis

All data were analyzed using Statistical Package for the Social Science (SPSS), version 25 (IBM Corp., Armonk, NY, USA). The internal reliability (Cronbach’s alpha) analysis was performed for the different scales of the CEBQ instrument. Pearson’s correlation was commuted to estimate the relationships between the mean items scale scores on each of the seven factors of the CEBQ questionnaire, and interpretation of the correlation coefficients was made according to Cohen’s descriptive guidelines [48]. Correlations between 0.1 and 0.3 were interpreted as small, correlations between 0.3 and 0.5 considered medium, and correlations between 0.5 and 1.0 large. The multinomial logistic regression was conducted to examine associations between scores of CEBQ subscales with children’s body weight status. Children’s weight category was the dependent variable, and NW was used as a reference point to the OW and OB groups. The difference in children’s weight status and maternal educational levels between CEBQ scores was ascertained using one-way ANOVA. The *p*-values generated were against normal weight category.

5.4 Results

In this study, 64.5% of the participants were NW, 18.9% were OW, and 16.6% were OB. The ages of participants ranged from 6 to 10 years with a mean age of the study sample being 8.42 years. There were no significant differences observed in age, gender, or maternal education. The characteristics of the participants and maternal education are given in our previously published manuscripts [43,44]. Internal reliability coefficients (Cronbach's alpha) for the different scales of the CEBQ are presented in Table 1 below. The Cronbach's alpha coefficients of the CEBQ subscales ranged from 0.784 to 0.915 and were all within acceptable range [49], which indicates that the CEBQ results have relatively high internal consistency.

Table 1. Factor structure and internal reliability of the child eating behavior questionnaire.

CEBQ	Mean ± SE	Cronbach
Food Responsiveness (FR)	1.96 ± 0.07	0.815
Enjoyment of Food (EF)	2.97 ± 0.06	0.798
Desire to Drink (DD)	2..23 ± 0.09	0.915
Emotional Overeating (EOE)	1.20 ± 0.06	0.872
Satiety Responsiveness (SR)	1.73 ± 0.05	0.784
Food Fussiness (FF)	1.73 ± 0.08	0.906
Emotional Undereating (EUE)	1.41 ± 0.07	0.796

SE—Standard error

Pearson bivariate correlations between CEBQ subscales are presented in Table 2. The correlations between the subscales indicate that food-avoidant subscales (satiety responsiveness) were negatively correlated to food approach subscales (food responsiveness ($r = -0.477$, $p < 0.001$) and enjoyment of food ($r = -0.495$, $p < 0.001$)) and positively correlated to food-avoidant subscale emotional undereating ($r = 0.267$, $p < 0.001$). Another food avoidance subscale, food fussiness, was also negatively correlated to food approach subscales food responsiveness ($r = -0.118$) and enjoyment of food ($r = -0.513$, $p < 0.001$). These were positively correlated to food-avoidant subscale emotional undereating ($r = 0.273$, $p < 0.001$). The food approach subscale food responsiveness was positively correlated to other food approach subscales such as enjoyment of food ($r = 0.418$, $p < 0.001$), desire to drink (r = 0.294, $p < 0.001$), and emotional overeating ($r = 0.53$, $p < 0.001$). Another positive correlation between food approach subscales was desire to drink and emotional overeating ($r = 0.279$ $p < 0.001$). In addition, one food-avoidant subscale, emotional undereating, and food approach subscale emotional overeating were positively correlated ($r = 0.281$ $p < 0.001$).

Table 2. Pearson's correlations between the subscales of child eating behavior questionnaire.

CEBQ Subscales	FR	EF	DD	EOE	SR	FF	EUE
Food responsiveness	1.000						
Enjoyment of food	0.418*	1.000					
Desire to drink	0.294*	0.094	1.000				
Emotional overeating	0.530*	0.144	0.279*	1.000			
Satiety responsiveness	-0.477*	-0.495*	-0.045	-1.130	1.000		
Food fussiness	-0.118	-0.513*	0.078	0.009	0.378*	1.000	
Emotional undereating	0.007	-0.251*	0.136	0.281*	0.267*	0.273*	1.000

The statistical significance in the table is shown as * $p < 0.001$ level.

Multinomial logistic regression was used to examine the association between subscale scores of CEBQ and children's body weight. The regression model was adjusted for confounding variables such as age, gender, and maternal education. A significant negative association was found with one food approach subscale (desire to drink) in the overweight category ($\beta = -0.511$, $p = 0.01$) and one food-avoidant subscale (satiety responsiveness) in the obese category ($\beta = -1.18$, $p = 0.001$). A positive association was found in the obese group with three food approach subscales, i.e., food responsiveness ($\beta = 0.865$, $p = 0.001$), enjoyment of food ($\beta = 0.633$, $p = 0.037$), and emotional overeating (β = 0.568, p = 0.032) in the obese group compared to normal weight (Table 3).

Table 3. Multinomial regression analysis for the overweight and obese groups (reference) category: normal weight (NW)) in the child eating behavior questionnaire (CEBQ) subscale (adjusted for age, gender, and maternal education).

	OW	***p* Value**	**OB**	***p* Value**
Food Approach				
Food responsiveness (FR)	-0.186 (0.24)	0.44	0.865 (0.26)	**0.001**
Enjoyment of food (EF)	0.172 (0.26)	0.51	0.633 (0.30)	**0.037**
Desire to drink (DD)	-0.511 (0.20)	**0.01**	-0.173 (0.20)	0.39
Emotional overeating (EOE)	-0.528 (0.29)	0.07	0.568 (0.26)	**0.032**
Food avoidance				
Satiety responsiveness (SR)	-0.303 (0.32)	0.34	-1.180 (0.37)	**0.001**
Food fussiness (FF)	-0.219 (0.20)	0.27	-0.134 (0.21)	0.53
Emotional undereating (EUE)	-0.037 (0.22)	0.87	0.06 (0.24)	0.80

Normal weight (NW), overweight (OW), obese (OB). Values are represented as β coefficient (SE). $p < 0.05$ considered significant and represented in bold.

Table 4 shows the mean scores of the CEBQ subscales based upon the children's weight status and maternal education. Results obtained from the one-way ANOVA revealed significant differences in three subscales, i.e., food responsiveness, desire to drink, and emotional overeating under food approach, which measure a child's interest in food with BMI. However, food responsiveness (p = 0.001) and emotional overeating (p = 0.003) were significantly increased in the OB group compared to NW and OW. Only one subscale, satiety responsiveness, under food avoidance, which measures children's lack of interest in food, was decreased significantly (p = 0.002) in the obese group compared to NW and OW (Figure 1a, b).

Table 4. One-way ANOVA of factors based on body weight and maternal education.

	Food Approach				**Food Avoidance**		
	FR	**EF**	**DD**	**EOE**	**SR**	**FF**	**EUE**
Body Mass Index							
NW (*n* = 109)	1.86(0.08)	2.89(0.80)	2.36(0.11)	1.19(0.08)	1.83(0.07)	1.81(0.10)	1.41(0.09)
OW (*n* = 32)	1.68(0.16)	2.99(0.12)	1.72(0.18)	0.90(0.13)	1.73(0.10)	1.58(0.18)	1.39(0.17)
OB (*n* = 28)	2.63(0.20)	3.27(0.14)	2.30(0.22)	1.61(0.18)	1.32(0.13)	1.61(0.21)	1.43(0.17)
p-value	**0.001**	0.086	**0.021**	**0.003**	**0.002**	0.435	0.988
Maternal Education							
High school or less (*n* = 40)	2.11(0.16)	3.06(0.13)	2.83(0.17)	1.32(0.17)	1.73(0.09)	1.73(0.14)	1.21(0.13)
Associate degree (*n* = 42)	2.29(0.14)	3.06(0.13)	2.53(0.17)	1.45(0.13)	1.55(0.12)	1.75(0.18)	1.57(0.14)
Bachelor's degree (*n* = 37)	1.64(0.14)	2.97(0.12)	1.85(0.18)	1.01(0.11)	1.84(0.11)	1.63(0.19)	1.28(0.17)
Graduate (*n* = 50)	1.79(0.13)	2.84(0.12)	1.78(0.15)	1.04(0.09)	1.81(0.10)	1.80(0.14)	1.53(0.13)
p-value	**0.008**	0.499	**0.001**	**0.037**	0.217	0.909	0.220

Results are expressed as mean (SE). $p < 0.05$ considered significant and represented in bold.

Food responsiveness (FR); enjoyment of food (EF); desire to drink (DD); emotional overeating (EOE); satiety responsiveness (SR); food fussiness (FF); emotional undereating (EUE).

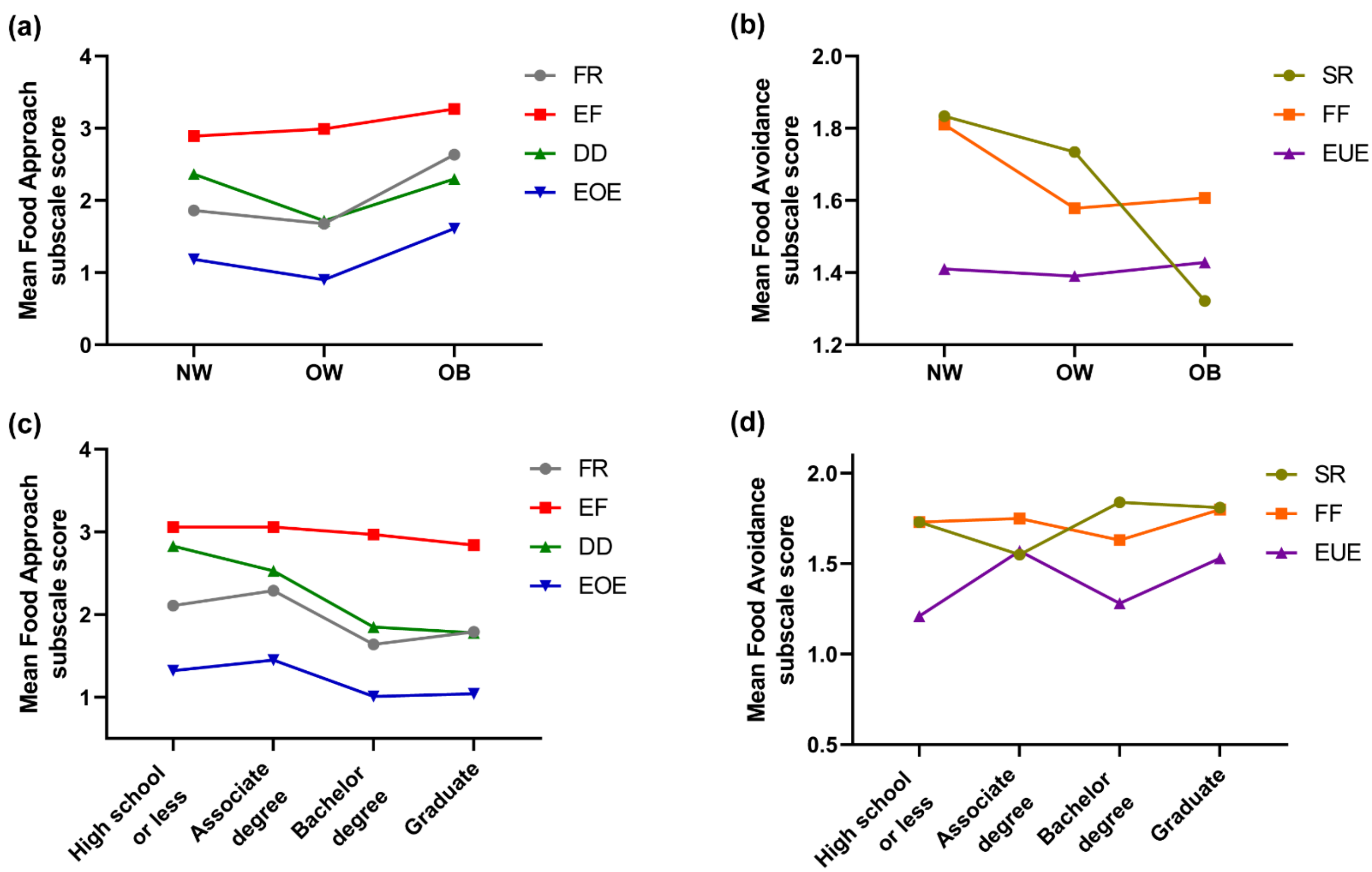

Figure 1. Mean scores of the subscales of food approach and food avoidance of the CEBQ based on (**a**, **b**) weight and (**c**, **d**) maternal education category.

In relation to maternal education in children's eating behaviors, the results reveal significant differences only in the food approach subscales, i.e., food responsiveness ($p = 0.008$), desire to drink ($p = 0.001$), and emotional overeating ($p = 0.037$). The mean scores showed that the children of mothers with a Bachelor's degree or graduate-level education had significantly decreased food responsiveness ($p = 0.008$), desire to drink ($p = 0.0001$), and emotional overeating ($p = 0.037$) compared to mothers with a lower education level (Figure 1c, d).

5.5 Discussion

This study investigated whether children's eating behaviors are different based on their weight status and maternal educational level. The findings revealed that obese children exhibited a higher interest in food due to increased scores of food responsiveness, enjoyment of food, and emotional overeating. Children with obesity were revealed to score relatively lower in satiety responsiveness, which measures children's lack of interest in food compared to that of children of normal weight. The previous results theoretically support these findings [41,50,51].

The relationship between these children's eating factors and maternal education was also evaluated. Findings in the mean scores for maternal education revealed that children of mothers with a Bachelor's degree or graduate level education showed significantly decreased food responsiveness, desire to drink, and emotional overeating compared to those of mothers with a lower education level. The food approach subscales were only dependent upon maternal education and not food avoidance. This is consistent with studies that have indicated that greater educational achievement among mothers may reduce their children's susceptibility to the cumulative nature of obesogenic factors [52–55].

Multinomial logistic regression testing the mean-scale scores revealed that children with obesity exhibited positive responsiveness, showing greater pleasure in eating, and emotionally overeating. The positive association of these food approach scales (food responsiveness, enjoyment of food, emotional overeating) with the BMI z-score is similar to results reported by others that demonstrate children with a higher BMI z-score tend to be greatly receptive to environmental food cues [39,41,50,51,56]. The only food approach subscale that revealed a negative association with the BMI z-score was desire to drink.

The present study has limitations; one of several is the location of the study. The study was carried out on the Auburn University campus. Therefore, participants were recruited in and around Auburn, Opelika, Beauregard, and Tuskegee in Alabama. In a college town, it is worth mentioning that parents may well be more interested in nutrition education compared to parents in non-college rural areas. Therefore, these findings may not be generalizable. Another limitation is the self-reporting nature of the CEBQ questionnaire, indicating that parents subjectively reported the children's eating behaviors. Moreover, this was not a longitudinal or experimental study; thus, inferences concerning causality should not be made. These findings show that more studies are needed to investigate the role of eating behaviors in the etiology of obesity in early childhood by hypothesizing whether individual eating style is the reason for weight gain or vice versa.

To the best of our knowledge, this is one of the few studies exploring the differences in individual eating styles in children that also includes maternal educational levels. Our findings indicate that there is an individual feeding difference between children of different weight status, and maternal educational level. However, further investigation is needed to determine the direction of the effect. Our findings may help in gaining insights into understanding the many pathways contributing to the etiology of early child weight gain, thereby designing appropriate nutrition interventions that will promote healthy feeding behaviors in children.

5.6 Conclusions

Our findings suggest that the increase in food responsiveness and emotional overeating in obese children are influenced by maternal education. Given that there is an association between maternal education and eating behavior in children, our results suggest that it is essential to compensate for the level of maternal education.

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Appendix 1

Study Questionnaire

Children's Eating Behavior Questionnaire **Please check one, there is no right or wrong answers**					
<u>Satiety responsiveness/Slowness in eating</u>	Never 0	Seldom 1	Half of the time 2	Most of the time 3	Always 4
My child gets full up easily					
My child has a big appetite					
My child leaves food on his/her plate at the end					
My child looks forward to mealtimes					
My child gets full before his/her meal is finished					
My child cannot eat a meal if s/he has had a snack just before					
My child eats slowly, takes more than 30 minutes					
My child finishes his/her meal very quickly					
<u>Fussiness</u>	Never 0	Seldom 1	Half of the time 2	Most of the time 3	Always 4
My child enjoys tasting new foods					
My child enjoys a wide variety of foods					
My child is interested in tasting food s/he hasn't tasted before					
My child refuses new foods at first					
My child decides that s/he doesn't like food, even without tasting it					
My child is difficult to please with meals					
<u>Food responsiveness</u>	Never 0	Seldom 1	Half of the time 2	Most of the time 3	Always 4
My child's always asking for food					
Given the choice, my child would eat most of the time					
If allowed to, my child would eat too much					
Even if my child is full up, s/he finds room to eat his/her favorite food					
<u>Enjoyment of food</u>	Never 0	Seldom 1	Half of the time 2	Most of the time 3	Always 4
My child enjoys and loves eating food					
My child is interested in food					
My child looks forward to mealtimes					

My child loves candy, cookies, donuts and other sweet snacks					
My child loves to eat fruits					
My child loves to eat vegetables					
Desire to drink	Never 0	Seldom 1	Half of the time 2	Most of the time 3	Always 4
If given the chance, my child would always be having a sugary drink					
If given the chance, my child would have sugary drink continuously throughout the day					
My child is always asking for a sugary drink					
Emotional undereating	Never 0	Seldom 1	Half of the time 2	Most of the time 3	Always 4
My child eats less when s/he is upset					
My child eats less when s/he is angry					
My child eats less when s/he is tired					
My child eats less when s/he does not watch TV/electronics					
Emotional overeating	Never 0	Seldom 1	Half of the time 2	Most of the time 3	Always 4
My child eats more when s/he is happy					
My child eats more when anxious					
My child eats more when annoyed					
My child eats more when worried					
My child eats more when s/he has nothing else					
My child eats more when watching TV/electronics					

Child Feeding Factors Questionnaire

To be filled by the parent

Please check one, there is no right or wrong answers

Perceived responsibility	Never 0	Seldom 1	Half of the time 2	Most of the time 3	Always 4
When your child is at home, how often are you responsible for feeding her?					
How often are you responsible for deciding what your child's portion sizes are?					
How often are you responsible for deciding if your child has eaten the right kind of foods?					
Perceived parent weight	Markedly underweight 0	Underweight 1	Normal 2	Overweight 3	Markedly overweigh t 4
Your Childhood (5 to 10 years old)					
Your adolescence					
Your 20s					
At present					
Perceived child weight	Markedly underweight 0	Underweight 1	Normal 2	Overweight 3	Markedly overweigh t 4
Your child during the first year of life					
Your child as a toddler					
Your child as a preschooler					
Your child kindergarten through 2nd grade					
At present					
Concern about child weight	Unconcerned 0	A little concerned 1	Concerned 2	Fairly concerned 3	Very concerned 4
How concerned are you about your child eating too much when you are not around her?					

How concerned are you about your child having to diet to maintain a desirable weight?					
How concerned are you about your child becoming over weight?					
Restriction	Disagree 0	Slightly disagree 1	Neutral 2	Slightly agree 3	Agree 4
I have to be sure that my child does not eat too many sweets (candy, ice cream, cake or pastries)					
I have to be sure that my child does not eat too many high-fat foods					
I have to be sure that my child does not eat too much of her favorite foods					
I intentionally keep some foods out of my child's reach					
I offer sweets (candy, ice cream, cake, pastries) to my child as a reward for good behavior					
I offer my child her favorite foods in exchange for good behavior					
If I did not guide or regulate my child's eating, she would eat too many junk foods					
If I did not guide or regulate my child's eating, she would eat too much of her favorite foods					
Pressure to eat	Disagree 0	Slightly disagree 1	Neutral 2	Slightly agree 3	Agree 4
My child should always eat all of the food on her plate					
I have to be especially careful to make sure my child eats enough					
If my child says ``I'm not hungry", I try to get her to eat anyway					
If I did not guide or regulate my child's eating, she would eat much less than she should					
Monitoring	Never 0	Seldom 1	Half of the time 2	Most of the time 3	Always 4

How much do you keep track of the sweets (candy, ice cream cake, pies, pastries) that your child eats?					
How much do you keep track of the snack food (potato chips, Doritos, cheese puffs) that your child eats?					
How much do you keep track of the high-fat foods that your child eats?					

		Getting to know you **Please answer these questions about your child** **there are no right or wrong answers**
1	Age	
2	Grade	
3	What is the name of your school?	
4	Sex (check one)	___ Female ____ Male
5	Race (check one)	____White Americans ____ African Americans
6	Birth weight	
7	Bedtime on school nights (check one)	____ At or before 7:00 pm ____ Between 7:00 pm to 7:30 pm ____ Between 7:30 pm to 8:00 pm ____ Between 8:00 pm to 8:30 pm ____ Between 8: 30 pm to 9:00 pm ____ After 9:00 pm
8	Do you go to bed at the same time on school nights?	____ Yes ____ No If no, how many days of the 5 school nights do you go to bed at the time you mentioned in question 7? __________
9	Wake up time on school days (check one)	____ At or before 5:00 am ____ Between 5:00 am to 5:30 am ____ Between 5: 30 am to 6:00 am ____ Between 6:00 am to 6:30 am ____ Between 6:30 am to 7:00 am

		____ After 7:00 am
10	What time do you have dinner during school days? (check one)	____ At or before 5:00 pm ____ Between 5:00 pm to 6:00 pm ____ Between 6: 00 pm to 7:00 pm ____ Between 7: 00 pm to 8:00 pm ____Between 8: 00 pm to 9:00 pm ____After 9:00 pm
11	Do you eat dinner at the same time on school nights?	____Yes ____No If no, how many days of the 5 school nights do you eat dinner at the time you mentioned in question 10? _____
12	How long do you watch TV, iPad, and video games on school nights (check one)	___ None ____ Between 0 to 30 min ____Between 30 min to 1 hour ____Between 1 to 2 hours ____More than 2 hours
13	Does your child have any health problems? If so please list.	
14	Does your child take any medications? If so list.	
15	Does your child have diabetes? (check one)	____ Yes ____ No If yes, is it: ___ type 1 diabetes or ___ type 2 diabetes? How old was your child when diagnosed with diabetes? ______

16	What medication does your child take for diabetes?	
17	Annual family income (check one)	____ Less than $25,000 ____ $25,000-$49,000 ____ $50,000- $74,0000 ____ $75,000 or more
18	Insurance plan (check one)	____ Private insurance ____ Public/state sponsored ____ Medicare/Medicaid ____ Other ____ None
19	Education of child's mother (check one)	____ Graduate degree ____ Bachelor's degree ____ Some college or associate degree ____ High school degree or equivalent ____ Less than high school degree
20	Has the child's mother been diagnosed with diabetes? (check one)	____ Yes ______ No If yes, is it: ____ type 1 diabetes or ____type 2 diabetes?
21	Has the child's father been diagnosed with diabetes? (check one)	____Yes ______ No If yes, is it: ______ type 1 diabetes or ____type 2 diabetes?