Sibship Composition, Mealtime Behaviors, and the Weight Status of Early School-Age Children

by

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DEDICATION

To *Hamza* and *Ammar…*

My beautiful children and the most precious pair of siblings I know.

Thank you for inspiring me everyday.

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ABSTRACT

Childhood obesity continues to be a public health concern, and effective intervention strategies are needed. Understanding the associations of family structure and functioning with child weight status can help inform family-based interventions and optimize their outcomes. The association between sibship composition (i.e., birth order and number and sex of siblings) and child weight status has not been well established or fully explored. The objective of this dissertation was to examine the association between sibship composition and child weight status, and to investigate maternal feeding behavior, child eating behavior, and sibling interactions during mealtimes as pathways underlying this association.

Three analytic samples (N=273, N=274, and N=75) were selected from an initial cohort of 301 low-income mother-child dyads based on specific inclusion criteria and covariates of interest for each study. Participants were recruited from Head Start facilities in South-Central Michigan. During study visits, participants completed questionnaires, anthropometry, and a videotaped laboratory mealtime observation. Participants also completed 3 videotaped family mealtime observations at home. Multiple logistic regression was used to examine the association of birth order and number and sex of siblings with odds of overweight or obesity. Path analysis was used to examine maternal feeding behavior as well as child eating behavior as mediators in the association of birth order with child overweight or obesity. Sibling interactions during mealtimes were coded from the family mealtime observation videos, and path analysis was used to examine encouragements to eat received by the index child (IC) from the sibling as a mediator in the association of birth order and sex of sibling with child body mass index z-score (BMIz).

Among the analytic sample of 273, only children and youngest siblings had higher odds of overweight or obesity compared to oldest siblings (OR: 4.18, 95% CI: 1.67,10.46 and OR: 3.21, 95% CI: 1.41,7.33, respectively). Having younger siblings and having at least one brother were associated with lower odds (OR: 0.38, 95% CI: 0.21,0.69 and OR: 0.47, 95% CI: 0.28,0.81, respectively). Among the analytic sample of 274, the association between only child status and greater likelihood of overweight or obesity was fully mediated by higher maternal discouragement to eat and lower maternal praise (all p values < 0.05). The association between youngest sibling status and greater likelihood of overweight or obesity was partially mediated by lower maternal praise and lower child food fussiness (all p values < 0.05). Among the analytic sample of 75, being the younger sibling in a sibling dyad was associated with the IC receiving more encouragements to eat from the sibling (β: 0.93, 95% CI: 0.59, 1.26, p<0.0001). However, the IC having a sister compared with a brother was not associated with receiving more encouragements to eat from the sibling (β: 0.18, 95% CI: -0.09, 0.47, p=0.20). The IC receiving more

encouragements to eat from the sibling was associated with lower IC BMIz (β: -0.06, 95% CI: -0.12, 0.00, *p*=0.05).

Findings from this dissertation suggest that sibship composition is cross-sectionally associated with child weight status, and that this association is mediated by mealtime behaviors. Future longitudinal studies are needed to establish temporality of events. Findings can help inform family-based obesity prevention programs by guiding recommendations for family mealtime interactions.

CHAPTER 1

Introduction

Theme

Obesity among children and adults is a widely recognized public health concern (Ebbeling, Pawlak, & Ludwig, 2002; Ogden, Carroll, Kit, & Flegal, 2014). Early prevention and intervention may contribute to achievement and maintenance of a healthy weight status (Epstein, Myers, Raynor, & Saelens, 1998). Therefore, identifying risk factors at early life stages has been a focus of many efforts (Reilly, et al. 2005). The home environment is a key target for understanding risk factors for childhood obesity and implementing intervention strategies (Davis et al., 2007; Golan & Crow, 2004; Knight, 1999; Pinard, et al., 2012). While it is well established that family structure and functioning are associated with various child outcomes (Bzostek & Beck, 2011; Hotz & Pantano, 2013; Lawson, Makoli, & Goodman, 2013; Waldfogel, Craigie, & Brooks-Gunn, 2010), their association with childhood obesity is not fully understood. Specifically, the association between sibship composition (i.e., birth order and number and sex of siblings) and child weight status is not well established. Mealtime behaviors of family members have been linked to child weight status (Birch, 2001; Klesges et al., 1983; Patrick, Nicklas, Hughes, & Morales, 2005; Rhee, Lumeng, Appugliese, Kaciroti, & Bradley, 2006).

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Although many studies have focused on mother-child interactions during mealtimes, there is a lack of understanding of how maternal feeding and child eating behaviors may vary by sibship composition. Additionally, interactions between siblings during mealtimes have not been previously evaluated. The objective of this dissertation was to examine the association between sibship composition, mealtime behaviors, and child weight status. In order to address the gaps in the literature, we analyzed data from early school age children and their mothers. Data analyzed included child and maternal anthropometry, sibship composition data, maternal-reported information regarding maternal feeding and child eating behaviors, and observational data of mother-child and sibling-child mealtime interactions.

The following sections of this chapter consist of: 1) a brief discussion of trends in childhood overweight and obesity; 2) an overview of the literature regarding sibship composition and relationships with child outcomes, including a summary of what is known regarding underlying pathways of association; 4) a discussion about sibship composition and relationships with child weight status, including an overview of potential underlying pathways of association; 5) a description of the study population used in this research; and 6) an overview of the succeeding chapters.

Childhood Overweight and Obesity

Overweight and obesity are conditions associated with increased risk of morbidity and mortality throughout the life cycle (Deckelbaum & Williams, 2001; Reilly & Kelly, 2011). Individuals with excess adiposity have a poorer quality of life in general and a lower life expectancy (Schwimmer, Burwinkle, & Varni, 2003; Weiss et al., 2004).

Comorbidities often exist in adults but are also manifested in overweight and obese children. Compared to healthy weight children, overweight and obese children have higher risk of insulin resistance, prediabetes, dyslipidemia, and hypertension (Daniels et al., 2005; Deckelbaum & Williams, 2001; Freedman, Mei, Srinivasan, Berenson, & Dietz, 2007; Li, Ford, Zhao, & Mokdad, 2009). Obese children are also more likely to experience psychological problems such as low self-esteem, depression, and anxiety (Csábi, Tenyi, & Molnar, 2000; Daniels et al., 2005). Additionally, one of the most important consequences of childhood overweight and obesity is the increased risk and severity of obesity in adulthood. Five-year old children who are overweight are 4 times as likely to be obese at age 14 as their healthy weight counterparts (Cunningham, Kramer, & Narayan, 2014), and obese adolescents are likely to become obese adults (Dietz, 1994). Obesity during adulthood is more difficult to treat (Epstein et al., 1998), and comorbidities are more substantial (Deckelbaum & Williams, 2001). Therefore, the need for successful intervention and prevention strategies for childhood overweight and obesity is immediate.

The prevalence of overweight and obesity among children in the US continues to be alarmingly high (Ogden et al., 2014). In 2012, about one third of 2-19 year olds were classified as overweight or obese (i.e., had a body mass index (BMI) $\geq$ the 85th percentile based on the US Centers for Disease Control and Prevention (CDC) growth charts for age and sex), and about 17% were obese (i.e., had a BMI $\geq$ the 95th percentile based on the CDC growth charts for age and sex)(Ogden et al., 2014). The prevalence of obesity was higher among racial/ethnic minorities (i.e., non-Hispanic Blacks and Hispanics), and among older age groups (Ogden et al., 2014).

The human body stores energy as fat when energy (in the form of kilocalories) input is greater than energy output. This process is regulated by many physiological mechanisms (Ebbeling et al., 2002). Individuals who have excess stores of body fat do so typically due to the presence of several factors influencing the process of energy regulation. Excess adiposity is likely to be caused by an interaction of behavioral, environmental, genetic, and early life factors (Ebbeling et al., 2002). Moreover, some of these underlying factors are tightly correlated. Behavioral factors, such as diet and physical activity, can be directly related to characteristics of the home environment (Ebbeling et al., 2002). For example, children who live in low-income homes are more likely to consume inexpensive processed foods that are high in sugar and saturated fat (Casey et al., 2006; Johnson, Guthrie, Smiciklas-Wright, & Wang, 1994). Children who live in low-income homes are also more likely to live with parents who have lower educational attainment and work longer hours, making them less able to support a healthy physical activity routine for their children (Evans, 2004; Suglia, Duarte, Chambers, & Boynton-Jarrett, 2012). Consequently, the home environment is thought to be an important venue for examining behavioral causes of childhood obesity and for implementing intervention and prevention strategies.

The family is a central component of the home environment. Whether or not an individual has siblings, in addition to characteristics of these siblings, can impact many features of the home environment. While there is still much work to be done in order to establish the associations between sibship composition and child weight status, the role of siblings in shaping child development and outcomes in different domains (e.g., psychosocial development and outcomes) is well documented in the literature (Baydar,

Greek, & Brooks-Gunn, 1997; Brody, 2004; Brody, Stoneman, & Burke, 1987; Dunn, 1983; Furman & Buhrmester, 1985; Gennetian, 2005; Hotz & Pantano, 2013; Lawson, Makoli, & Goodman, 2013). Understanding how sibship composition relates to different child outcomes can guide research studies aiming to identify the association between sibship composition and childhood overweight and obesity. In the following sections, we first summarize some of what is known regarding how sibship composition relates to child outcomes in general. Then, we discuss how sibship composition may relate to, more specifically, child weight status.

Sibship Composition and Relationships with Child Outcomes

Over the last 3 decades, there has been a growing appreciation for the importance of siblings in influencing many aspects of an individual's life (Lamb, 1982; Trent & Spitze, 2011; Lawson, Makoli, & Goodman, 2013; Volling, 2012). Although many have tracked associations of sibship composition with personality and achievement into adulthood (Lamb, 1982; Trent & Spitze, 2011), the most significant associations with behavioral outcomes are observed during earlier stages of development (Baydar et al., 1997; Downey, Condron, & Yucel, 2015; Dunn, Kendrick, & MacNamee, 1981; Stewart, Mobley, Tuyl, & Salvador, 1987; Trent & Spitze, 2011; Volling, 2012). A birth of a new sibling is considered a complex adjustment period that is associated with short- and long-term effects (Baydar et al., 1997; Dunn et al., 1981; Nadelman & Begun, 1982; Stewart et al., 1987; Volling, 2012). For toddlers and preschoolers, short-term behaviors associated with the birth of a sibling include negative behaviors, such as withdrawal and overall distress, as well as positive behaviors, such as an increased desire to be independent, enhanced

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language skills, and nurturing behaviors (Dunn et al., 1981; Nadelman & Begun, 1982; Stewart et al., 1987; Volling, 2012).

Among early school age children, having a younger sibling is associated with development of enhanced language and teaching skills and favorable school performance outcomes, whereas having an older sibling is linked to improved social skills and peer interactions (Brody, 2004; Brody, Stoneman, & MacKinnon, 1982; Downey, Condron, & Yucel, 2015; Maynard, 2002; Paulhus, Trapnell, & Chen, 1999; Zukow-Goldring, 1995). Similar to first-borns, children who grow up without siblings (i.e., only children) have been found to have positive cognitive and academic achievement outcomes (Falbo, 1982), although compared to children who have siblings, they were found not do as well in negotiating peer relationships (Downey & Condron, 2004; Downey, Condron, & Yucel, 2015). In addition to number of siblings, trends between sex of siblings and educational outcomes have also been detected (Powell & Steelman, 1990).

Underlying Pathways of Association

Pathways by which sibship composition are associated with child outcomes in different domains are well documented in the early and recent literature, and they include 1) parenting behavior and 2) direct siblings' encounters with one another (i.e., sibling interactions) (Brody, 2004; Brody et al., 1987; Dunn, 1983; Dunn & Plomin, 1991; Hotz & Pantano, 2013).

Parenting Behavior

A birth of a sibling is associated with significant, often permanent changes in the family environment, as well as a change in the child's birth order (Baydar et al., 1997).

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Changes in these circumstances are accompanied by modifications in parental behaviors, which have important implications with regard to child development.

Increase in the number of siblings is associated with dilution of time and resources (Blake, 1981), which is associated with changes in the quality and level of mother-child interactions (Baydar et al., 1997). However, although increase in the number of siblings may increase the risk of financial hardship, studies show that number of siblings is positively associated with marital stability (Katzev, Warner, & Acock, 1994; Nielsen, Videbech, Hedegaard, Dalby, & Secher, 2000; Rogers & White, 1998), which can be associated with higher parenting satisfaction. Gender and age of siblings have also been linked to marital stability and parenting behavior (Katzev et al., 1994; Nielsen et al., 2000; Rogers & White, 1998). For example, having a brother and younger age of siblings is associated with higher paternal involvement and engagement with family members, which is related to greater maternal parenting satisfaction, and positive child outcomes (Katzev et al., 1994; Rogers & White, 1998; Schor, 2003; Waite & Lillard, 1991).

Child birth order is associated with parents' expectations and their use of rules and disciplinary strategies (Brody, 2004; Hotz & Pantano, 2013). For example, parents usually have higher academic expectations and employ more stringent parenting with first-borns, which has been linked to better school performance of oldest siblings (Hotz & Pantano, 2013). Only children who grow up without siblings are also likely to be subjected to more rules and boundaries and higher expectations as a result of increased parental attention, which might contribute to the observed positive educational outcomes among only children (Hotz & Pantano, 2013).

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Sibling Interactions

Throughout childhood, siblings are usually constant companions who spend a substantial amount of time together (Lamb, 1982). Therefore, relationships between siblings are strongly associated with children's behavioral development (Brody, 2004; Dunn, 1983). Findings from research studies have linked direct sibling interactions with child personality and temperament, self-esteem, psychosocial, and school performance outcomes (Brody, 2004; Dunn & Plomin, 1991; Stocker, Dunn, & Plomin, 1989). It is important to note that, as explained below, children may experience different interaction patterns with their siblings depending on their birth order and the sex of the sibling (Brody, 2004; Brody et al., 1982; Dunn, 1983), which may contribute to the observed associations between sibship composition and child outcomes.

In general, interactions between young siblings can resemble either parent-child interactions or peer interactions (Dunn, 1983; Harrist et al., 2014). Complementarity is a term for features of sibling interactions that resemble parent-child interactions. In this type of interaction, one sibling is usually the dominant individual and the other usually submits (Brody et al., 1982; Dunn, 1983; Harrist et al., 2014). Examples of complementarity include caregiving and teaching, which are most often initiated by older siblings and sisters (Brody et al., 1982; Dunn, 1983; Stewart & Marvin, 1984; Zukow-Goldring, 1995). The superior school performance often observed in older siblings has been attributed, at least in part, to the caregiving role that they often assume. It is thought that by acting as teachers for their younger siblings, older siblings gain language, cognitive, and communication skills as well as higher self-esteem (Brody, 2004; Dunn, 1983). As for younger siblings,

this type of interaction highlights the importance of older siblings as a resource for gaining knowledge and forming beliefs and perceptions.

Reciprocity is a term for features of sibling interactions that resemble peer interactions. In this type of interaction, children understand each other and share common interests (Dunn, 1983; Harrist et al., 2014). Imitation and affect (both negative and positive) are examples of reciprocity. Older siblings are considered powerful role models whom younger siblings are likely to imitate (Dunn, 1983; Harrist et al., 2014), and the sex of the sibling was also found to influence the degree of imitation (Frazier, Gelman, Kaciroti, Russell, & Lumeng, 2012).

Sibship Composition and Relationships with Child Weight Status

Contrary to child outcomes in other domains, the association between sibship composition and child weight status has not been established or fully explored. There have been conflicting reports regarding the association of birth order and number of siblings with child BMI (Chen & Escarce, 2010; Haugaard, Ajslev, Zimmermann, Angquist, & Sorensen, 2013; Hesketh, Crawford, Salmon, Jackson, & Campbell, 2007; Hunsberger et al., 2012; Jelenkovic, Silventoinen, Tynelius, Myrskyla, & Rasmussen, 2013; Koziel, 2001; Lissau, Inge, Sorensen, & Lissau, 1994; Ochiai et al., 2012; Siervo, Horta, Stephan, Victora, & Wells, 2010; Stettler et al., 2000; Wells et al., 2011). Some studies reported a higher risk of obesity of only children (Chen & Escarce, 2010; Haugaard et al., 2013; Hesketh, Carlin, Wake, & Crawford, 2009; Hesketh et al., 2007; Hunsberger et al., 2012; Ochiai et al., 2012) and youngest siblings (Haugaard et al., 2013; Ochiai et al., 2012), while others found that only children and youngest siblings were less likely to be obese

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(Jelenkovic et al., 2013; Koziel, 2001; Stettler et al., 2000). Some studies found an inverse

association between number of siblings and risk of obesity (Chen & Escarce, 2010), while

others found no association (Lissau et al., 1994). Furthermore, the association between sex

of siblings and child weight status has not been previously evaluated. Understanding the

association between sibship composition and child weight status can help practitioners and

researchers better identify children at risk for overweight and obesity. Furthermore,

including multiple family members in intervention programs may improve outcomes

(Kaplan, Arnold, Irby, Boles, & Skelton, 2013). Identifying the underlying processes of the

association between sibship composition and child weight status can guide

recommendations involving behaviors related to siblings, which can help enhance family-

based programs.

Potential Underlying Pathways of Association

Given the rising evidence supporting the role of mealtime behaviors with regard to

associations with childhood obesity, we consider the underlying pathways described earlier

(i.e., parenting behavior and sibling interactions) in the context of mealtimes in order to

understand how sibship composition may relate to child weight status. The following

section summarizes how mealtime behaviors, including maternal feeding behaviors, child

eating behaviors, and sibling mealtime interactions, may serve as potential underlying

pathways of association.

Maternal Feeding Behaviors

Since, in general, parents have been shown to use different parenting practices

(with varying degrees of expectation and control) depending on the child's birth order and

number of siblings (Brody, 2004; Hotz & Pantano, 2013; Nye, Carlson, & Garrett, 1970),

parents may also modify their parenting practices in the context of mealtimes.

A parent's approach to feeding and modifying the child's behavior during

mealtimes has been characterized along two general parenting dimensions; demandingness

and responsiveness (Hughes, Power, & Fisher, 2005; Hughes, Power, Fisher, Mueller, &

Nicklas, 2005; Hughes, Shewchuk, Baskin, Nicklas, & Qu, 2008; Rhee et al., 2006).

Demandingness refers to the degree to which parents show supervision and control in their

parenting, while responsiveness refers to the degree to which parents show support,

warmth, and involvement in their parenting (Hughes et al., 2005; Hughes et al., 2008).

Highly demanding authoritarian feeding practices characterized by high control and low

support include monitoring, restriction, punishment, pressure to eat, bribery, and coercion

(Faith, Scanlon, Birch, Francis, & Sherry, 2004). A positive association between

demanding maternal feeding behaviors and child BMI has been observed in several studies

(Faith et al., 2004; Moens, Braet, & Soetens, 2007; Rhee et al., 2006). It has been

suggested that excessive demandingness and maternal restriction during mealtimes affects

the child's ability to self-regulate and accurately respond to internal cues of satiety, leading

to higher caloric intake and increased adiposity (Birch & Fisher, 1998; Drucker, Hammer,

Agras, & Bryson, 1999; Fisher & Birch, 1999, 2002; Johnson & Birch, 1994).

Furthermore, children who experience excessive restriction may overcompensate when the

restricted food becomes available to them (Birch & Fisher, 1998; Drucker et al., 1999;

Fisher & Birch, 1999, 2002; Johnson & Birch, 1994).

Feeding practices that are highly responsive, such as exerting appropriate control in a warm and supportive manner, have been associated with a healthy weight status and diet quality (Gable & Lutz, 2000; Patrick et al., 2005). Parents who actively encourage eating by using predominantly nondirective and supportive behaviors (e.g., reasoning and allowing choice of appropriate foods) were found to have children who consume more fruits and vegetables (Patrick et al., 2005; Rhee et al., 2006). Therefore, adaptive parental involvement, support and praise may encourage internalized control and healthy eating behaviors among children (Patrick et al., 2005; Stanek, Abbott, & Cramer, 1990; Vereecken, Keukelier, & Maes, 2004).

The association between birth order and child weight status might be mediated by maternal feeding behaviors. For example, in general, children who have no siblings receive undivided attention from their mother (Hotz & Pantano, 2013). This increased maternal attention may be manifested in excessive control during mealtimes. In addition, parents were shown to alter their expectations with a last-born child due to previous experiences with older siblings (Brody, 2004), and they also tend to have less time to spend with the youngest sibling (Hotz & Pantano, 2013). These circumstances may be associated with unique feeding practices of last-born children that may be characterized by varying degrees of involvement and support.

Child Eating Behaviors

Child eating behaviors can influence the quantity and quality of food intake, potentially affecting weight status (Birch & Fisher, 1998; Wardle, Guthrie, Sanderson, & Rapoport, 2001). In general, children modify their behavior in response to observed

behaviors of other children (Dunn, 1983; Pepler, Abramovitch, & Corter, 1981). This can also be observed during mealtimes, where eating with peers was found to be associated with changes in eating behaviors (e.g., speed of eating and food preferences) among children (Birch, 1980; Lumeng & Hillman, 2007). Furthermore, among school age children, eating alone (i.e., with no adults or children present) has been linked to eating behaviors characterized by increased food intake (Tanofsky-Kraff et al., 2007). Since youngest siblings are likely to eat with older siblings, who can be influential role models, and since only children may be more likely to eat alone, child eating behaviors is a potential underlying pathway for the association between birth order and weight status.

Examples of specific child eating behaviors identified in the literature that have been linked to child weight status include slowness in eating (i.e., the child's speed of eating), satiety responsiveness (i.e., the child's response to internal cues of satiety), food responsiveness (i.e., the child's response to external cues such as the sight and smell of food), and food fussiness (i.e., the child's willingness to eat novel and different types of foods (Birch & Fisher, 1998; Wardle et al., 2001)).

Siblings Mealtime Interactions

Children often spend more time with siblings than with parents (Kramer & Conger, 2009; Updegraff, McHale, Whiteman, Thayer, & Delgado, 2005), and are often seated with siblings during mealtimes. Although the role of siblings as caregivers and role models is widely recognized, little attention has been given to examine sibling behaviors during mealtimes; we were unable to identify any studies reporting evaluations of sibling interactions during a naturalistic mealtime setting. The relationship of sibling mealtime

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interactions with child eating behaviors and weight status has not been previously explored. Since the nature of sibling interactions may be predicted by sibling's birth order and sex (Dunn, 1983), and since family mealtime interactions have been associated with child obesity risk (Faith et al., 2004; Moens et al., 2007), sibling mealtime interactions is a potential underlying pathway for the association between sibship composition and child weight status.

Study Population

Data used for analysis in this dissertation were obtained from 301 child-mother dyads recruited through Head Start programs in South Central Michigan. Head Start is a federally subsidized preschool program for low-income, high-risk families in the US. Most participants were drawn from a longitudinal cohort initiated in 2009 to investigate associations between stress and eating among low-income children. To reach the target sample size of 300 participants, the cohort was augmented with 18 additional caregiver-child dyads that were recruited in May 2013 by flyers distributed to Head Start locations describing a study on feeding behavior. Children were between the ages of 4 and 8 years at the time of data collection. Inclusion criteria were: caregiver is fluent in English and does not have a college degree; and child is not in foster care, has no serious medical problems or history of food allergies and was born at $\geq$ 35 weeks gestation without significant perinatal or neonatal complications. The sample was restricted as appropriate for each study described in this dissertation.

Mothers provided written informed consent for themselves and for their children, and each mother was compensated $150 for participating in all study procedures. The

University of Michigan Institutional Review Board approved this study.

Thesis Overview

Chapter 2 investigates the associations between birth order and number and sex of siblings with child overweight or obesity. Potential confounders and intermediate variables were taken into account.

Chapter 3 examines reported and observed maternal feeding behavior as well as maternal reported child eating behavior as underlying pathways for the association between birth order and child overweight or obesity.

Chapter 4 evaluates interactions between sibling pairs during a naturalistic mealtime setting as an underlying pathway for the association between birth order and sibling's sex with child BMI z-score.

Chapter 5 summarizes the work of this dissertation and discusses implications and future directions.

CHAPTER 2

Birth Order and Sibship Composition as Predictors of Overweight or Obesity among Low-Income 4-8 Year Old Children

Abstract

Objective: To examine the association of birth order and number and sex of siblings with overweight or obesity among 4-8 year olds.

Methods: This is a cross-sectional study involving 273 low-income mother-child dyads. Questionnaires and anthropometry were completed. Multiple logistic regression analysis was used to examine the association of birth order, having younger siblings, having older siblings, having at least one brother, and having at least one sister with odds of overweight or obesity. Analyses were repeated to additionally include non-biological siblings. Models were adjusted for potential confounders and intermediate variables.

Results: Prevalence of child overweight or obesity was 42.5%. Adjusting for covariates, only children and youngest siblings had higher odds of overweight or obesity compared to oldest siblings (OR: 4.18, 95% CI: 1.67,10.46 and OR: 3.21, 95% CI: 1.41,7.33,

respectively). Having one or more younger siblings and having at least one brother were associated with lower odds (OR: 0.38, 95% CI: 0.21,0.69 and OR: 0.47, 95% CI: 0.28,0.81, respectively). Including non-biological siblings did not meaningfully change the associations.

Conclusion: Birth order and sibship composition are associated with overweight or obesity among 4-8 year olds. Future studies identifying the underlying behavioral pathway can help inform family-based intervention programs.

Background

In 2012, a third of United States (US) children and adolescents were estimated to be overweight or obese (Ogden et al., 2014). Identifying children who have higher obesity risk can help researchers and practitioners target interventions more effectively. In addition, understanding the underlying mechanisms for increased risk can help enhance these interventions and optimize their outcomes. Although specific demographic characteristics, such as socioeconomic status (SES), have received substantial attention in the prior literature, associations of birth order and sibship composition (i.e., number and sex of siblings) with childhood obesity are not well established. As divorce rates have increased and fertility rates have decreased, families have become smaller and the number of children growing up without other children in the household has increased (Vespa, Lewis, & Kreider, 2013). These shifts in family structure and size during the past three decades now make it especially important to understand the associations of birth order and sibship composition with childhood obesity. Because more US children are now growing up with fewer brothers and sisters or without siblings, examining these associations can help target and inform obesity preventive interventions for a relatively large proportion of the population.

A number of reports have described a conflicting set of findings regarding the association of birth order and number of siblings with weight status (Chen & Escarce, 2010; Haugaard et al., 2013; Hesketh et al., 2009; Hesketh et al., 2007; Hunsberger et al., 2012; Jelenkovic et al., 2013; Koziel, 2001; Lissau et al., 1994; Ochiai et al., 2012; Stettler et al., 2000; Wells et al., 2011). Some studies have found that being an only child (Chen &

Escarce, 2010; Haugaard et al., 2013; Hesketh et al., 2009; Hesketh et al., 2007; Hunsberger et al., 2012; Ochiai et al., 2012) or a youngest sibling (Haugaard et al., 2013; Ochiai et al., 2012) was associated with a higher risk of obesity. However, other studies have reported that only children and youngest siblings were less likely to be obese (Jelenkovic et al., 2013; Koziel, 2001; Stettler et al., 2000), and others have reported no association (Lissau et al., 1994; Wells et al., 2011). Some reports have described an inverse association of number of siblings (Chen & Escarce, 2010), or number of younger siblings (Ochiai et al., 2012) with risk of obesity. However, others found no association (Lissau et al., 1994). These discrepant findings may be due to methodological distinctions, including differences in the definition of birth order categories (i.e., combining only children and oldest siblings in the same comparison group vs. allocating them in separate categories) and age of study participants.

There are several additional gaps in the existing literature. First, potential confounders such as maternal education, which may be associated with both parity (Lovenheim & Mumford, 2013) and child weight status (Chen & Escarce, 2010), were often not considered. In addition, most studies did not take into account potential intermediate variables (e.g., maternal relationship status), which can help us determine whether the associations are entirely explained by these variables, or whether future studies are needed to explore the potential underlying pathways of association. Second, to our knowledge, no prior study in the US has tested the hypothesis that being a youngest sibling is an independent predictor of weight status (Haugaard et al., 2013; Ochiai et al., 2012). Third, siblings' sex characteristics have been associated with perceived parenting behavior

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(Raley & Bianchi, 2006) and outcomes of a family-based obesity intervention (Epstein, Paluch, & Raynor, 2001), but prior studies have not examined the association between sex of siblings and child weight status (Chen & Escarce, 2010; Haugaard et al., 2013; Hesketh et al., 2007; Hunsberger et al., 2012; Ochiai et al., 2012). Finally, most studies (Chen & Escarce, 2010; Haugaard et al., 2013; Hunsberger et al., 2012; Ochiai et al., 2012) did not specifically focus on low-income groups that are at significantly higher risk of obesity (Ogden et al., 2014).

The goals of this study were to examine the associations of only child status, youngest sibling status, and sibship composition (i.e., number and sex of siblings) with odds of overweight or obesity in low-income US families while taking into account potential confounders and intermediate variables.

Methods

Participants and Procedures

The study sample includes 301 child-mother dyads that were recruited through Head Start programs in South Central Michigan for a study about feeding behaviors (full study sample described in Chapter 1, "Study Population"). Because this study takes into account maternal weight, which might influence the child's weight status through hereditary factors and early life exposures, we limited the sample to participants living with their biological mothers (n=281). Five children with missing data and three children who had a same age sibling were also excluded for accurate categorization of children's birth order, leaving a final sample of 273. The sample included in this analysis (n = 273) did not differ from the sample not included (n = 28) with regard to child sex, child

race/ethnicity, and maternal education. Mothers provided written informed consent for themselves and for their children. The University of Michigan Institutional Review Board approved this study.

During 2 study visits, mothers completed questionnaires alone and anthropometric measurements were taken from mothers and children. Due to the high prevalence of low literacy in this sample, research assistants read questions and response options aloud from a computer, and then entered mothers' answers.

Measures

Study Outcome: Child Overweight or Obesity Status

Trained staff members measured weight and height following standardized procedures. Shoes and heavy clothing were removed. Each individual was weighed twice and if the two readings were inconsistent by more than 0.1 kg, the individual was weighed two more times. Similarly, height was measured twice, if the measurements differed by more than 0.5 cm, two more measurements were taken. All available measures were averaged for analysis. Body mass index (BMI) was calculated by dividing weight (kg) by height^2 (m^2), and percentiles were derived based on the revised Centers for Disease Control growth charts. A BMI $\geq$ the 85th percentile was categorized as overweight or obese (OWOB).

Primary Predictors: Birth Order and Sibship Composition

Mothers provided information regarding individuals living in the household, including each individual's age, sex, and relationship to the index child. The 5 primary predictors created from this information were: 1) a 4-category variable for birth order,

categorized as only child, youngest sibling, middle sibling, and oldest sibling. Disjoint

indicator variables were used for each birth order category, with "oldest sibling" as the

reference category; 2) A dichotomous variable for having one or more younger siblings; 3)

A dichotomous variable for having one or more older siblings; 4) A dichotomous variable

for having at least one brother; 5) A dichotomous variable for having at least one sister.

We defined these variables in two alternative ways. First, we included only biologically

related siblings in our definitions. Secondly, to examine differences by biological

relatedness of siblings, we created these variables again additionally including non-

biological siblings living in the same household as the index child (n=51). In both analyses

we retained all (n=273) index children in the study sample.

Covariates

We identified additional characteristics for which to adjust in our statistical models

a priori from the literature. Mothers reported information regarding sociodemographic

characteristics, including child's sex, child's age, child's race/ethnicity, and mother's

birthdate, years of education, and relationship status. The 18-item US Department of

Agriculture Food Security Scale (Nord, Andrews, & Carlson, 2005) was used to create a 2-

level variable to categorize households as food secure or food insecure. Mothers completed

the 20-item Center for Epidemiologic Studies-Depression scale (CES-D) and a score $\geq$ 16

(Radloff & Locke, 1986) defined clinically significant depression symptoms. Mothers'

weight and height were measured using standardized procedures and BMI was calculated.

Mothers reported the child's birth weight, which was converted to z-scores based on

National Datasets(Oken, Kleinman, Rich-Edwards, & Gillman, 2003). Birth weight z-scores were missing and were imputed for 26 subjects using Proc MI in SAS.

Statistical Analysis

Statistical analyses were conducted using IBM SPSS Statistics 21.0 (Armonk, NY, USA). We ran descriptive statistics to assess characteristics of the full sample, and bivariate analyses by OWOB status using t-tests for continuous variables and Chi-square tests for categorical variables.

We ran separate logistic regression models for each of the 5 primary predictors. We first ran the regression models without adjusting for any covariates. Then, we reran the models controlling only for potential confounders, including child's sex, child's age, child's race/ethnicity, maternal age, and maternal education. Each of these variables might be associated with fertility choices (Lovenheim & Mumford, 2013; Raley & Bianchi, 2006; Rindfuss & Bumpass, 1976; U.S. National Center for Health Statistics, National Vital Statistics Report, 2008), which may affect the number of brothers and sisters a child has as well as his/her birth order (e.g., being an only child vs. not). Child's sex, child's age, child's race/ethnicity, maternal age, and maternal education are also associated with child overweight (Chen & Escarce, 2010; Ogden et al., 2014 ; Whitaker, 2004). Next, in order to examine the direct effect of each of the primary predictors on weight status, we reran the models to additionally include covariates that may be located in the causal pathway. Birth order (being an only child vs. not) and number of brothers and sisters have been associated with maternal relationship status (Raley & Bianchi, 2006), amount of resources available (Trent & Spitze, 2011) (measured here as household food insecurity), maternal depression

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symptoms (Dodge & Silva, 1980), maternal BMI (Abrams, Heggeseth, Rehkopf, & Davis, 2013; Whitaker, 2004) and child birth weight (Oken et al., 2003; Whitaker, 2004). Each of these variables has in turn been associated with child overweight (Chen & Escarce, 2010; Duarte, Shen, Wu, & Must, 2012; Rose & Bodor, 2006; Whitaker, 2004). We therefore included them as potential intermediate variables in the 5 fully adjusted models. The Wald test statistic was used and significance level was set at 0.05. Furthermore, we included in each of the fully adjusted models an interaction term of index child sex with the primary predictor and tested if the interaction term was statistically significant (P-value < 0.10). Finally, we reran each of these 5 fully adjusted models replacing the primary predictor variables with their versions that also included non-biological siblings.

Results

About half of the children were male (50.9%). Mean child age was 5.4 years (± SD 0.8) and approximately half of the children (53.8%) were non-Hispanic white. The prevalence of OWOB in the sample was 42.5%. Mean maternal BMI was higher among OWOB children (36.3 ± SD 10.0) compared to non-OWOB children (30.6 ± SD 8.3). Children who were OWOB also had higher birth weights (Table 2-1). Thirty-nine children (14.3%) were only children, 100 (36.6%) were youngest siblings, 66 (24.2%) were middle siblings, and 68 (24.9%) were oldest siblings. In unadjusted bivariate analyses, birth order and having one or more younger siblings were associated with prevalence of OWOB status. Having at least one brother was associated with higher prevalence of non-OWOB status (Table 2-1).

Birth Order and Child Overweight or Obesity

As shown in Table 2-2, adjusting for all covariates, only children had higher odds of being OWOB compared to oldest siblings (Odds Ratio (OR): 4.18, 95% confidence interval (CI): 1.67, 10.46). Youngest siblings had higher odds of being OWOB compared to oldest siblings (OR: 3.21, 95% CI: 1.41,7.33). The OR for middle siblings to oldest siblings was 1.71 (95% CI: 0.76, 3.86, P-value= 0.19). The OR for youngest siblings to only children was 0.77 (95% CI: 0.33,1.80, P-value= 0.54). The odds of being OWOB for middle siblings compared to only children approached statistical significance (OR: 0.41, 95% CI: 0.17,1.00, P-value= 0.05), as did the odds for middle siblings compared to youngest siblings (OR: 0.53, 95% CI: 0.25,1.11, P-value=0.09).

Sibship Composition and Child Overweight or Obesity

As shown in Table 2-2, having one or more younger siblings was associated with lower odds of overweight or obesity (OR: 0.38, 95% CI: 0.21, 0.69). However, having one or more older siblings was not significantly associated with odds of being OWOB (OR: 1.28, 95% CI: 0.71, 2.31, P-value=0.41). Having at least one brother was associated with lower odds of being OWOB (OR: 0.47, 95% CI: 0.28,0.81). Having at least one sister had no significant association with odds of being OWOB (OR: 1.10, 95% CI: 0.64,1.89, P-value= 0.72).

Interaction with Index Child's Sex

There was no significant interaction between index child's sex and any of the 5 primary predictors (all P-values > 0.50).

Inclusion of Non-biological Siblings

When we reran the analyses replacing each of the primary predictor variables with their versions that also included non-biological siblings, the results were essentially unchanged (Table 2-3).

To examine whether the associations differ between children who are overweight as compared to those who are obese, we conducted a multinomial regression analysis with a 3-category outcome variable (obese status, overweight status, non-overweight or obese status). Results suggested that the patterns of associations are the same across children who are overweight as compared to those who are obese.

Discussion

We found that being an only child or the youngest sibling as well as having no younger siblings or no brothers was each associated with higher odds of overweight or obesity. Results were not attenuated by inclusion of maternal, child and family characteristics that may be located in the causal pathway, and were essentially unchanged when non-biological siblings were included in the analysis. These findings suggest that factors other than the ones considered here might explain the associations of birth order and sibship composition with child overweight or obesity.

Our findings are consistent with previous studies identifying a positive association between being an only child and overweight risk (Chen & Escarce, 2010; Haugaard et al., 2013; Hesketh et al., 2007; Hunsberger et al., 2012; Ochiai et al., 2012). Although an earlier study found that not having siblings is not associated with obesity, this finding was based on data from Dutch adults in the 1970s (Lissau et al., 1994), with a relatively low

prevalence of obesity. To our knowledge, our study is the first in the US to report that youngest siblings may have higher odds of overweight or obesity. This finding is consistent with 2 previous studies in non-US populations (Haugaard et al., 2013; Ochiai et al., 2012); the studies that did not find this association combined oldest siblings and only children into the same comparison group, which may be masking effects (Jelenkovic et al., 2013; Koziel, 2001; Stettler et al., 2000). In consensus with an earlier study (Ochiai et al., 2012), we observed that having younger siblings was associated with lower odds of overweight or obesity. In addition, although we could not identify any previous studies that examined the association between siblings' sex and children's weight status, we found that having at least one brother was also associated with lower odds of overweight or obesity.

Birth order (e.g., being an only child) and number of brothers and sisters might affect marital status (Raley & Bianchi, 2006), and children of single mothers are at higher risk of obesity (Chen & Escarce, 2010). Having more siblings can be associated with fewer available resources (Trent & Spitze, 2011) and food insecurity has been associated with lower risk of obesity among school-age children (Rose & Bodor, 2006). In addition, mothers with larger family sizes can be at higher risk for depression (Dodge & Silva, 1980), which has been associated with childhood obesity (Duarte et al., 2012). However, adjusting for maternal relationship status, household food insecurity, and maternal depression symptoms did not change our results. Maternal weight (Abrams et al., 2013) and child birth weight (Oken et al., 2003) tend to increase with parity, and higher maternal BMI and child birth weight are each associated with childhood obesity (Whitaker, 2004), However, when we included maternal BMI and child birth weight z-score in our models,

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the associations were not attenuated. These findings suggest that there may be other unrelated factors contributing to the underlying pathway of association.

Behavioral characteristics and interaction patterns between family members may be the underlying pathway explaining the association of birth order and sibship composition with weight status. For example, parenting behaviors in general have been shown to vary by children's birth order (Trent & Spitze, 2011). This suggests that parenting behaviors specific to feeding, which can affect weight status (Hughes et al., 2008), might also vary by birth order. Having more younger siblings may lead to more time spent in play, increasing caloric expenditure throughout the day, and having at least one brother can be associated with more positive interactions between family members (Raley & Bianchi, 2006), and hence better family functioning during mealtimes. Future studies are needed to test these potential underlying behavioral processes.

This study has several strengths. We explored the associations of birth order and sibship composition with weight status in a low-income, multiethnic US population. Additionally, we were uniquely positioned to further account for previously unexamined variables. Our study was the first to specifically examine the effect of siblings' sex, and to distinguish between biological and non-biological siblings. This study also has some limitations. Our sample size is relatively small and therefore our power to detect some effects may have been limited. There might be residual confounding (e.g., by SES) or potential intermediate variables (e.g., physical activity) that we did not account for in our analysis. In addition, we did not measure or examine the influence of siblings' weight. Because our study included only Head Start families who chose to respond to a flyer, our

findings may not be generalizable to individuals without these characteristics. Finally, our findings may only be relevant to 4-8 year olds. It remains unknown if the effect of birth order and sibship composition persists later into the lifespan, but the pattern of findings in the existing literature suggests that the association weakens with age, since most of the observed positive associations were seen in school-age children (Chen & Escarce, 2010; Haugaard et al., 2013; Hesketh et al., 2009; Hesketh et al., 2007; Hunsberger et al., 2012; Ochiai et al., 2012) as opposed to adolescence and adulthood (Jelenkovic et al., 2013; Koziel, 2001; Lissau et al., 1994; Stettler et al., 2000).

Conclusion

Our findings support our hypothesis that sibship composition is associated with child weight status. Since we speculate that associations observed in this study are driven by family routines and functioning, further studies that aim to understand these underlying processes can help inform family-based interventions. Including multiple members of the family can improve obesity intervention outcomes (Kaplan et al., 2013). Our findings may motivate practitioners and researchers to explore parenting practices of only children and of youngest siblings as a component of family-based programs. Future efforts may also include discussing with parents different interaction patterns between siblings and how they may relate to obesity risk. Parents can be influential in shaping relationships between siblings (Kramer, 2004), and can therefore be educated to encourage sibling interactions that are associated with healthy eating and physical activity. Using birth order and sibship composition data could become a novel and successful approach to identify children at risk

and to tailor recommendations involving the home setting, which can contribute to efforts

aiming to help lower pediatric obesity rates.

Table 2-1*: Characteristics of Total Sample and differences by Weight Status

Variables	Total n= 273	BMI < 85th Percentile n= 157	BMI ≥ 85th Percentile n=116	P-value
Birth Order, n (%)				
Only child	39 (14.3)	16 (10.2)	23 (19.8)	0.02
Youngest sibling	100 (36.6)	53 (33.8)	47 (40.5)	
Middle sibling	66 (24.2)	41 (26.1)	25 (21.6)	
Oldest sibling	68 (24.9)	47 (29.9)	21 (18.1)	
Index Child has ≥ 1 Younger Sibling, n (%)				
Yes	134 (49.1)	88 (56.1)	46 (39.7)	0.01
No	139 (50.9)	69 (43.9)	70 (60.3)	
Index Child has ≥ 1 Older Sibling, n (%)				
Yes	166 (60.8)	94 (59.9)	72 (62.1)	0.80
No	107 (39.2)	63 (40.1)	44 (37.9)	
Index Child has ≥ 1 Brother, n (%)				
Yes	112 (41.0)	104 (66.2)	57 (49.1)	0.01
No	161 (59.0)	53 (33.8)	59 (50.9)	
Index Child has ≥ 1 Sister, n (%)				
Yes	142 (52.0)	80 (51.0)	62 (53.4)	0.68
No	131 (48.0)	77 (49.0)	54 (46.6)	
Child Sex, n (%)				
Male	139 (50.9)	88 (56.1)	51 (44.0)	0.05
Female	134 (49.1)	69 (43.9)	65 (56.0)	
Child Race/Ethnicity, n (%)				
Non-Hispanic white	147 (53.8)	91 (58.0)	56 (48.3)	0.13
Hispanic or not white	126 (46.2)	66 (42.0)	60 (51.7)	
Maternal Age, M (SD)	30.4 (5.80)	30.6 (6.2)	30.02 (5.2)	0.43
Maternal Education, n (%)				
≤ High school education	129 (47.3)	78 (49.7)	51(44.0)	0.28
> High school education	144 (52.7)	79 (50.3)	65(56.0)	
Mather's Relationship Status, n (%)				
Single	123 (45.1)	71 (45.2)	52 (44.8)	1.00
Not single	150 (54.9)	86 (54.8)	64 (55.2)	
Household Food Insecurity, n (%)				
Food secure	84 (30.8)	52 (33.1)	32 (27.6)	0.35
Food insecure	189 (69.2)	105 (66.9)	84 (72.4)	
Maternal Depressive Symptoms, n (%)				
CES-D ≥ 16	85 (31.1)	49 (31.2)	36 (31.0)	1.00
CES-D < 16	188 (68.9)	108 (68.8)	80 (69.0)	
Maternal BMI, M (SD)	33.0 (9.45)	30.6 (8.28)	36.3 (9.96)	0.00
Birth weight z-score, M (SD)	-0.27 (1.02)	-0.43 (0.91)	-0.042 (1.12)	0.00

* Table showing means (M) and standard deviations (SD) or counts (n) and percentages (%). Significance of differences between weight status groups tested by t-tests for continuous variables and chi-square tests for categorical variables.
δ CES-D: The Center for Epidemiologic Studies-Depression scale. BMI: body mass index.

Table 2-2 Associations between Birth order and Sibship Composition with Odds of Overweight or Obesity (BMI $\geq 85^{th}$ percentile) Including Only Biological Siblings

	Unadjusted Odds Ratios (95% CI) (n=273)	Odds Ratios (95% CI) (n=273) Adjusted for confounders only[1]	Odds Ratios (95% CI) (n=273) Adjusted for confounders and intermediate variables[2]
Birth Order Category:			
Only child	3.22 (1.42, 7.30)**	3.68 (1.55, 8.68)**	4.18 (1.67, 10.46)**
Youngest sibling	2.00 (1.04, 3.79)*	2.71 (1.27, 5.77)**	3.21 (1.41, 7.33)**
Middle sibling	1.39 (0.67, 2.79)	1.68 (0.79, 3.61)	1.71 (0.76, 3.86)
Oldest sibling (Reference)	1	1	1
Index Child has ≥ 1 Younger Sibling			
Yes	0.51 (0.31, 0.83)**	0.44 (0.26, 0.77)**	0.38 (0.21, 0.69)**
No (Reference)	1	1	1
Index Child has ≥ 1 Older Sibling			
Yes	1.09 (0.67, 1.79)	1.24 (0.72, 2.16)	1.28 (0.71, 2.31)
No (Reference)	1	1	1
Index Child has ≥ 1 Brother			
Yes	0.50 (0.30, 0.81)**	0.49 (0.30, 0.81)**	0.47 (0.28, 0.81)**
No (Reference)	1	1	1
Index Child has ≥ 1 Sister			
Yes	1.11 (0.68, 1.79)	1.16 (0.71, 1.91)	1.10 (0.64, 1.89)
No (Reference)	1	1	1

[1]Models adjusted for potential confounders only; child sex, child age, child race/ethnicity, maternal age, and maternal education.
[2]Models adjusted for potential confounders; child sex, child age child race/ethnicity, maternal age, and maternal education and potential intermediate variables; maternal relationship status, household food insecurity, maternal depression symptoms, maternal BMI and birth weight z-score.
* P-value < 0.05
** P-value < 0.01

Table 2-3 Associations between Birth order and Sibship Composition with Odds of Overweight or Obesity (BMI ≥ 85th percentile) Including Both Biological and Non-biological Siblings

	Unadjusted Odds Ratios (95% CI) (n=273)	Odds Ratios (95% CI) (n=273) Adjusted for confounders only[1]	Odds Ratios (95% CI) (n=273) Adjusted for confounders and intermediate variables[2]
Birth Order Category:			
Only child	3.33 (1.40, 7.74)**	3.88 (1.56, 9.63)**	4.39 (1.66, 11.61)**
Youngest Sibling	2.21 (1.13, 4.34)*	3.07 (1.41, 6.67)**	3.68 (1.57, 8.60)**
Middle Sibling	1.63 (0.79, 3.34)	2.01 (0.97, 4.48)	2.26 (0.99, 5.10)
Oldest Sibling (Reference)	1	1	1
Index Child has ≥ 1 Younger Sibling			
Yes	0.53 (0.33, 0.87)*	0.47 (0.27, 0.82)**	0.42 (0.23, 0.76)**
No (Reference)	1	1	1
Index Child has ≥ 1 Older Siblings			
Yes	1.24 (0.75, 2.05)	1.44 (0.82, 2.51)	1.52 (0.84, 2.76)
No (Reference)	1	1	1
Index Child has ≥ 1 Brother			
Yes	0.50 (0.31, 0.82)**	0.50 (0.30, 0.83)**	0.48 (0.28, 0.83)**
No (Reference)	1	1	1
Index Child has ≥ 1 Sister			
Yes	1.15 (0.70, 1.86)	1.23 (0.74, 2.03)	1.24 (0.72, 2.15)
No (Reference)	1	1	1

[1]Models adjusted for potential confounders only; child sex, child age, child race/ethnicity, maternal age, and maternal education. [2]Models adjusted for potential confounders; child sex, child age, child race/ethnicity, maternal age, and maternal education and potential intermediate variables; maternal relationship status, household food insecurity, maternal depression symptoms, maternal BMI and birth weight z-score.
* P-value < 0.05
** P-value < 0.01

CHAPTER 3

Higher Weight Status of Only and Last-Born Children: Maternal Feeding and Child Eating Behaviors as Underlying Processes among 4-8 Year Olds

Abstract

Objective: Birth order has been associated with childhood obesity. The objective of this cross-sectional study was to examine maternal feeding and child eating behaviors as underlying processes for increased weight status of only children and youngest siblings. Methods: Participants included 274 low-income 4-8 year old children and their mothers. The dyads completed a videotaped laboratory mealtime observation. Mothers completed the Caregiver's Feeding Styles Questionnaire and the Children's Eating Behavior Questionnaire. Child weight and height were measured using standardized procedures. Path analysis was used to examine associations of birth order, maternal feeding behaviors, child eating behavior, and child overweight or obese status.

Results: The association between only child status and greater likelihood of overweight or obesity was fully mediated by higher maternal Verbal Discouragement to eat and lower maternal Praise (all p values < 0.05). The association between youngest sibling status and greater likelihood of overweight or obesity was partially mediated by lower maternal Praise and lower child Food Fussiness (all p values < 0.05).

Conclusion: Results provide support for our hypothesis that maternal control and support and child food acceptance are underlying pathways for the association between birth order and weight status. Future findings can help inform family-based programs by guiding family counseling and tailoring of recommendations for family mealtime interactions.

Background

Childhood obesity rates in the United States (US) continue to be excessively high

(Ogden et al., 2014). Although evidence for effective intervention strategies is scarce,

family-based programs can be effective in achieving and maintaining weight loss among

preschool and school-age children (Epstein, Valoski, Wing, & McCurley, 1994; Kaplan et

al., 2013; Quattrin et al., 2012). Understanding how family structure is associated with

child weight status can help inform family-based programs and allow efficient tailoring of

recommendations that involve interactions between family members. Such interventions

are especially needed for low-income children who may live in chaotic and unstable homes

(Evans, 2004), and who are at higher risk for obesity (Ogden et al., 2014).

Birth order has been found to be associated with child overweight and obesity

(Haugaard et al., 2013; Hesketh et al., 2007; Hunsberger et al., 2012; Mosli et al.; Ochiai et

al., 2012). Although findings are inconsistent, studies that examined only children, oldest

siblings, and youngest siblings in separate birth order categories found that only children

and youngest siblings have higher risk of obesity compared to oldest siblings (Haugaard et

al., 2013; Hesketh et al., 2007; Hunsberger et al., 2012; Mosli et al.; Ochiai et al., 2012).

The underlying process for increased obesity risk of only children and youngest siblings is

not well established (Chen & Escarce, 2010; Haugaard et al., 2013; Hunsberger et al.,

2012). This is primarily due to the use of less comprehensive behavioral measures in

previous studies and/or less discrete categorization of birth order (i.e., combining only

children and oldest siblings in the same comparison group) (Chen & Escarce, 2010;

Drucker et al., 1999; Duke, Bryson, Hammer, & Agras, 2004; Haugaard et al., 2013;

Hesketh et al., 2007; Hunsberger et al., 2012; Ochiai et al., 2012). Evidence from social science research suggests that children within the same family can experience a non-shared home environment and dissimilar parenting behavior (Dunn & Plomin, 1991; Hotz & Pantano, 2013; Kidwell, 1981). Such behavioral variations might explain the association between birth order and weight status.

Parents often use different disciplinary strategies with first-born compared to later born children (Hotz & Pantano, 2013; Kidwell, 1981), and siblings may interact differently among each other depending on their sex and birth order (Kidwell, 1981). Only children experience a unique home environment, which may be characterized by greater parental attention (Trent & Spitze, 2011). Greater parental attention may be manifested in well-established rules and boundaries. On the other hand, the home environment of a youngest sibling might be characterized by less parental involvement and less stringent parenting practices compared to first-born children (Hotz & Pantano, 2013). The home environment of a youngest sibling also includes the presence of older siblings who can act as potent role models and secondary caretakers (Abramovitch, Corter, & Lando, 1979; Dunn, 1983). These distinctive behavioral interaction features of the home environment may also operate in the mealtime context and play a role in shaping child weight status.

Highly demanding and controlling parental feeding practices, such as restriction and pressure to eat, have been associated with maladaptive eating behaviors and higher weight status among children (Drucker et al., 1999; Fisher & Birch, 1999, 2002; Johnson & Birch, 1994). It has been suggested that such parenting practices may alter the child's ability to self-regulate and respond to internal satiety cues, leading to overeating and

weight gain (Drucker et al., 1999; Faith et al., 2004; Fisher & Birch, 1999, 2002; Johnson & Birch, 1994). However, appropriate control that is exerted in a warm and supportive manner has been associated with a healthy weight status, such that adaptive parental involvement and praise may encourage internalized control and healthy eating behaviors (Patrick et al., 2005; Rhee et al., 2006; Stanek et al., 1990; Vereecken et al., 2004).

In the context of general parenting, only children compared to youngest siblings experience different degrees of parent control and involvement (Conley & Glauber, 2006 ; Hotz & Pantano, 2013; Kidwell, 1981). Therefore, we hypothesized that feeding-specific parenting might show the same pattern. That is, excessive control and/or inadequate involvement during mealtimes may act as potential mediators in the association between only child or youngest sibling status and child overweight or obesity.

Another potential pathway involving mealtimes through which birth order might predict child weight status is the child's own eating behavior. The way a child behaves towards food (e.g., his/her response to satiety cues) can influence the quantity and quality of food consumed (Birch & Fisher, 1998; Wardle et al., 2001), and child eating behavior is associated with weight status and obesity risk (Birch & Fisher, 1998; Johnson & Birch, 1994; Wardle et al., 2001). Children are known to alter their eating behavior in response to the presence of other children (Salvy, Vartanian, Coelho, Jarrin, & Pliner, 2008; Birch, 1980 ; Lumeng & Hillman, 2007). Since older siblings are known to exert powerful role-modeling influences on younger siblings (Abramovitch et al., 1979; Birch, 1980), and older children typically consume larger quantities of food than younger children (Piernas & Popkin, 2011), youngest siblings may be imitating the behavior of older siblings and eat

larger quantities of food in the presence of their older siblings. Therefore, the eating behavior of youngest siblings might be characterized by high acceptance of food and increased food intake. Only children may also exhibit unique eating behaviors due to the absence of other children during home meals. For example, only children may be more likely to eat alone, and among school-aged children, eating alone has been associated with lower satiety responsiveness and increased food intake in the absence of hunger (Tanofsky-Kraff et al., 2007)(i.e., decreased use of internal signals of hunger and satiety as a basis for adjusting energy intake and responding with a desire to eat when a palatable food becomes freely available, even when not feeling physically hungry (Birch & Fisher, 1998; Fisher & Birch, 1999)). We therefore hypothesized that child eating behavior is a potential mediator in the association between birth order and child weight status.

In summary, the present study examined maternal feeding and child eating behaviors as underlying processes that may contribute to increased weight status of only children and youngest siblings.

Methods

Participants and Procedures

The study sample includes 301 child-mother dyads that were recruited through Head Start programs in South Central Michigan for a study about feeding behaviors (full study sample described in Chapter 1, "Study Population"). We limited the sample to participants living with their biological mothers with complete data on all variables (n = 277), as this represented the majority of the sample. Three children who only had same age siblings were also excluded, leaving a final analytic sample of 274, which did not differ

from the sample not included (n = 27) with regard to child sex, child race/ethnicity, or

maternal education. Mothers completed informed consents for themselves and for their

children, and each mother was compensated $150 for participating in all study procedures.

The University of Michigan Institutional Review Board approved this study.

Measures

Demographic Characteristics

Mothers reported the child's birthdate, sex and race/ethnicity as well as information

regarding individuals living in the household, including each individual's age and

relationship to the index child. This information was used to categorize each index child

into one of the birth order categories: only child, youngest sibling, middle sibling (defined

as having at least 1 older sibling and at least 1 younger sibling), and oldest sibling.

Mothers also reported their own birthdate and years of education.

Maternal Feeding Behaviors

Maternal feeding behaviors were coded during an observational eating protocol and

assessed using a self-report questionnaire.

Observed Feeding Behavior: Each child-mother dyad participated in a structured

eating protocol from which maternal feeding behavior was later coded. Dyads were seated

at a table in a quiet room and video-recorded while sampling 4 different types of foods

presented individually and sequentially in random order. The 4 types of food included a

generic familiar and unfamiliar vegetable, and a generic familiar and unfamiliar dessert.

This approach uniquely provides an opportunity to assess the mother's feeding practices

with the target child in a standardized procedure that may elicit a range of feeding practices

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with different types of food. Bob and Tom's Method of Assessing Nutrition

(BATMAN)(Klesges et al., 1983) was used to code maternal behavior during the meal.

The BATMAN is an observational assessment that evaluates certain parent behaviors that

may modify the child's eating behavior (Klesges et al., 1983). Verbal Encouragement and

Verbal Discouragement are behaviors evaluated by the BATMAN that we included in this

analysis. Other behaviors evaluated by the BATMAN, such as physical discouragement,

were observed to be relatively rare and thus have been excluded from this analysis. Verbal

Encouragement is operationalized as directing, suggesting, commanding, and making

positive statements in order to get the child to eat. Verbal Discouragement is

operationalized as forbidding, scolding, refusing, and making negative statements about, or

verbally limiting the child from eating the food. Two coders rated each of these behaviors

during the time periods when child-mother dyads were observed with each of the 4 foods

and behaviors were summed across foods. Inter-rater reliability was calculated for 20% of

tapes. Intraclass correlation coefficients (ICC) for both Verbal Encouragement and Verbal

Discouragement were each 1.0, indicating perfect agreement (Cicchetti, 1994).

Self-Reported Feeding Behavior: Mothers completed the Caregiver's Feeding

Styles Questionnaire (CFSQ), an instrument specifically developed to assess feeding styles

among low-income families (Hughes et al., 2005), with 5-point Likert response scales

ranging from 1 = never to 5 = always (Appendix A). The scale is typically used to

characterize mothers' general feeding behaviors as more or less demanding and responsive.

For the purposes of the current study, we sought to examine specific feeding behaviors in

more detail. Thus, we conducted a factor analysis that generated three subscales reflecting

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specific dimensions of maternal feeding behavior: verbal direction, coercion, and praise.

Scores were calculated as the mean of contributing items, with higher scores reflecting

more of the given behavior. The Verbal Direction score consisted of 4 items (Cronbach's

$\alpha= 0.74$) concerning how often mothers verbally suggest or command the child to eat. The

Coercion score consisted of 5 items (Cronbach's $\alpha= 0.82$) concerning how often mothers

use threats, bribes, and food as a reward in order to get the child to eat. Finally, the Praise

score consisted of 2 items (Cronbach's $\alpha= 0.73$) concerning how often mothers say

something positive about the child or the food.

Child Eating Behavior

Mothers completed the Children's Eating Behavior Questionnaire (CEBQ); a 35-

item questionnaire frequently used to assess eating styles in children through parental

report (Wardle, Guthrie, Sanderson, & Rapoport, 2001), with 5-point Likert response

scales ranging from 1 = never to 5 = always (Appendix B). The CEBQ generates subscales

by calculating the mean of the contributing items, with higher scores reflecting more of the

given behavior. In this analysis, we examined 3 subscales that evaluate behaviors that are

salient in peer interactions, and which a child might modify in response to presence of an

older sibling role model. For example, in the presence of older children, younger children

may eat faster and eat a larger quantity of food (Lumeng & Hillman, 2007). Children may

also alter their food preferences in response to observing foods consumed by older children

role models (Birch, 1980). Therefore, the 3 subscales we examined were Slowness in

Eating, which includes 4 items (Cronbach's $\alpha = 0.76$) concerning the child's speed of

eating; Satiety Responsiveness, which includes 5 items (Cronbach's $\alpha = .73$) concerning

how often the child finishes meals and maternal perceptions of the child's appetite; and

Food Fussiness, which includes 6 items (Cronbach's α = .85) concerning the willingness of

the child to eat different types of foods and novel foods.

Anthropometry

Trained staff members measured child weight and height following standardized

procedures. Shoes and heavy clothing were removed. Each child was weighed twice and if

the two readings were inconsistent by more than 0.1 kg, the individual was weighed two

more times. Similarly, height was measured twice and if the measurements differed by

more than 0.5 cm, two more measurements were taken. Body mass index (BMI) was

calculated by dividing weight (kg) by height in meters, squared. To categorize children's

weight status, percentiles were derived based on the US Centers for Disease Control and

Prevention age and sex specific growth charts (Ogden & Flegal, 2010). A BMI $\geq$ the 85th

percentile for age and sex was categorized as overweight or obese (OWOB). Mothers

reported the child's birth weight, which was converted to z-scores based on National

Centers for Health Statistics Natality Datasets (Oken et al., 2003). Birth weight z-scores

were missing and were imputed for 26 subjects using multiple imputations.

Statistical Analysis

Descriptive analyses were conducted using IBM SPSS Statistics 21.0 (Armonk,

NY, USA). We examined characteristics of the full sample by calculating the distribution

of demographic characteristics, birth weight z-score, birth order, and maternal feeding and

child eating behavior variables. We tested differences in these variables by child OWOB

status; by running t-tests for continuous variables and Chi-square tests for categorical

variables. In addition, we used Analysis of Variance (ANOVA) to detect significant differences in maternal feeding and child eating behaviors by 4-category birth order.

We used path analysis to examine processes underlying the association between birth order and child OWOB. Specifically, we conducted path analysis in MPLUS version 7.2 (Muthen & Muthen, Los Angeles, CA, USA) to test both the direct and indirect associations between birth order, maternal feeding behaviors, child eating behavior, and child OWOB status. Significance level was set at 0.05. Birth order, the predictor in the model, was included as a categorical variable with "oldest sibling" as the reference category. We screened potential meditators by identifying maternal feeding behavior and child eating behavior variables that differed by both child OWOB status and child birth order (using a conservative $p < 0.15$) and included them in the path model. We used the Bayesian estimation technique to fit the path model, as it contained both binary and continuous variables. The model was adjusted for child race/ethnicity, child sex, and child birth weight z-score. Paths between variables and child OWOB status that were non-significant and did not improve goodness of fit were removed in order to obtain the most parsimonious model with better fit. We conducted Bayesian posterior predictive checks (PPC) using Chi-square statistics and the corresponding posterior predictive p-values to assess goodness of fit of the model (Gelman, Carlin, Stern, & Rubin, 2003).

Results

The final sample size was 274. Mean child age was 5.4 years, and the prevalence of OWOB was 42.3%. Table 3-1 shows the distribution of demographic characteristics, birth weight z-score, birth order, maternal feeding and child eating behaviors for the total

sample, as well as by OWOB status. In bivariate analyses, birth order, maternal feeding and child eating behaviors were associated with OWOB status (Table 3-1), and maternal feeding and child eating behaviors were associated with birth order (Table 3-2).

Variables that met the first prerequisite for mediation, an association with birth order, included maternal Verbal Encouragement, maternal Verbal Discouragement, maternal Praise, and child Food Fussiness. However, only 3 of these variables also met the second prerequisite for mediation, an association with OWOB status. These variables were maternal Verbal Discouragement, maternal Praise, and child Food Fussiness. We thus proceeded with the 3 variables to build our path model. Results of the path analysis are shown in Figure 1. The path model showed good fit, with a posterior predictive p-value equal to 0.67, well within the 0.05-0.95 range.

As shown in Figure 3-1, only child status was associated with higher maternal Verbal Discouragement. Only child and youngest sibling status were associated with lower maternal Praise. In addition, youngest sibling and middle sibling status were associated with lower child Food Fussiness. Higher maternal Verbal Discouragement and lower maternal Praise and child Food Fussiness were associated with greater likelihood of child OWOB. There was a marginally significant direct association between youngest sibling status and child OWOB (Standardized β: 0.14, 95% confidence interval (CI): -0.024, 0.34, p-value: 0.08). The association between child sex and OWOB status was not significant (p-value: 0.26), and was therefore removed it from the model. Child birth weight z-score was positively associated with OWOB (Standardized β: 0.21, 95% CI: 0.09-0.36, p < 0.001). Non-significant control variables were not in the final model (Figure 3-1).

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In summary, the association between only child status and OWOB was eliminated once maternal Verbal Discouragement and Praise were entered into the model, suggesting that the association between only child status and greater likelihood of OWOB was fully mediated by higher maternal Verbal Discouragement and lower maternal Praise. Moreover, the association between youngest sibling status and OWOB was diminished after including maternal Praise and child Food Fussiness in the model, suggesting that the association between youngest sibling status and greater likelihood of OWOB was partially mediated by lower maternal Praise and lower child Food Fussiness.

Discussion

Results provided support for our hypothesis that the mealtime interaction features play a role in the association between birth order and child overweight or obesity. Specifically, we found that birth order was associated with maternal feeding behaviors and child eating behavior, which in turn were associated with child OWOB.

For only children, we found that maternal control and support were involved in the pathway of association between only child status and greater likelihood of OWOB. Mothers of only children were observed to use more verbal discouragement to eat during videotaped laboratory sessions. This type of maternal behavior is consistent with a previous study that found that only children were more likely to have parents supportive of food as a reward (as reported by parents via rating 8 statements pertaining to attitudes regarding using food as a reward) (Hunsberger et al., 2012), and using food as a reward represents the use of food rules that may lead to maladaptive eating behaviors (Puhl & Schwartz, 2003). Others found that first-born children were observed to experience more

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verbal encouragement to eat from their mothers (Drucker et al., 1999; Duke et al., 2004), which can also represent increased maternal control. However, in these previous reports, only children and oldest siblings were both included in the definition of "first-born" children, and findings thus may not necessarily apply uniquely to only children. The present study thus elaborated on prior work in at least two ways, first by addressing methodological limitations by using observational and self-reported assessment of maternal behavior and second by examining only children separately from oldest siblings.

Although excessive control has been consistently associated with higher risk of child obesity (Drucker et al., 1999; Fisher & Birch, 1999, 2002; Johnson & Birch, 1994), maternal support and praise has been associated with a healthy diet and weight status among children (Rhee et al., 2006; Patrick et al., 2005; Stanek et al., 1990; Vereecken et al., 2004). Mothers of only children in this study reported praising their children less frequently compared to mothers of oldest siblings, and only children were in turn more likely to be OWOB. The measure of praise used in this study included mothers' positive comments about healthy eating behavior and praise of healthy foods in front of the child. Thus, less-frequent praise of healthy eating behavior for only children may reflect less focus on these topics that may be important for the development of healthy eating behaviors (Patrick et al., 2005; Stanek et al., 1990; Vereecken et al., 2004).

Similarly, among youngest siblings, maternal support and praise may play a role in the pathway of association between younger sibling status and higher weight status. As with only children, mothers of youngest siblings also reported praising their children less frequently compared to mothers of oldest siblings, and youngest siblings were in turn more

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likely to be OWOB. In addition, we found that child eating behavior might underlie the association between youngest sibling status and higher likelihood of OWOB. Mothers of youngest siblings reported that their children were less fussy about food and were more likely to consume unfamiliar foods than did mothers of oldest siblings. Although lower food fussiness can be associated with higher consumption of fruits and vegetables (Galloway, Yoonna, & Birch, 2003), it may also be associated with increased food intake in general and higher weight status (Galloway, Fiorito, Lee, & Birch, 2005). Lower food fussiness has been previously associated with higher BMI among preschoolers and school-age children (Dubois, Farmer, Girard, Peterson, & Tatone-Tokuda., 2007; Galloway et al., 2005; Webber, Hill, Jaarsveld, & Wardle, 2008). Although no prior study has examined food fussiness as a potential pathway for increased weight among youngest siblings, earlier studies have found that children tend to eat more when older children are present (Birch, 1980; Salvy, Vartanian, Coelho, Jarrin, & Pliner, 2008). Therefore, lower food fussiness among youngest siblings may reflect youngest siblings modifying their eating behavior in response to their birth order status, for example by modeling what their older siblings do.

Our study has several limitations. First, this is a cross-sectional study that cannot test causality. There might also have been other potential mediators that were not examined in this analysis, and while our study only included maternal feeding behavior, the behavior of other family members (e.g., the father) might contribute to the underlying pathways. Future studies that measure additional possible mediating processes and use longitudinal designs are needed to further support our findings. Second, our study cohort only included low-income Head Start families who chose to respond to a flyer inviting them to

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participate in a research study about children's eating behavior. Thus, our findings may not be generalizable to families without these characteristics. Finally, our sample size is relatively small. Larger studies with higher power would be helpful in examining pathways in more detail.

Strengths of this study include our use of multiple methods and more accurate definitions of birth order categories in order to examine processes that could explain associations between child birth order and weight status. We have included both observational and self-report measures to examine maternal and child behaviors as pathways underlying the association between birth order and weight status. Finally, our low-income, racially diverse sample had a high prevalence of overweight/obesity.

Including multiple family members as part of obesity treatment programs can be associated with more positive child outcomes (Kaplan, Arnold, Irby, Boles, & Skelton, 2013). Since our findings suggest that mothers of only children may use more restrictive feeding practices, and that these only children are at higher risk of obesity, counseling mothers of only children about these associations may strengthen prevention and intervention programs. Although mothers may use restrictive feeding practices as a reaction to the child being already overweight (Faith et al., 2004), these types of feeding behaviors are believed to further promote obesogenic eating behaviors and result in additional weight gain over time (Fisher & Birch, 2002). Educating mothers of only children on how to adopt less demanding and more supportive feeding behaviors may be helpful. Furthermore, since our findings suggest that last-born children may be more willing to consume a variety of different types of foods, researchers and practitioners may

recommend that mothers of last-born children be especially mindful of available food choices. In addition, since the child's eating behavior may drive maternal restriction (Gregory, Paxton, & Brozovic, 2010), discussing how to respond to the child's eating behavior (e.g., greater food intake) with mothers of last-born children is warranted.

Conclusion

The association between child birth order and weight status might operate through maternal control and support and child food fussiness during mealtime. Results of our study can provide a framework for researchers and practitioners to consider when designing family-based programs for overweight or obese children. Interventions that are sensitive to the relationship between family structure and mealtime behaviors of family members may be more successful and may contribute to efforts that aim to lower childhood obesity rates.

Table 3-1[*] Demographic, Birth Weight Z-Score, Birth Order, Maternal Feeding, and Child Eating Characteristics of the Full Sample and Differences by Overweight or Obese Status

Variables	Total n = 274	BMI < 85th Percentile n = 158	BMI ≥ 85th Percentile n = 116	P-value
Child Sex, n (%)				
Male	139 (50.7)	88 (55.7)	51 (44)	0.06
Female	135 (49.3)	70 (44.3)	65 (56)	
Child Race/Ethnicity, n (%)				
Non-Hispanic white	147 (53.6)	91 (57.6)	56 (48.3)	0.13
Hispanic or not white	127 (46.4)	67 (42.4)	60 (51.7)	
Birth Order, n (%)				
Only child	39 (14.2)	16 (10.1)	23 (19.8)	0.02
Youngest sibling	100 (36.5)	53 (33.5)	46 (39.7)	
Middle sibling	66 (24.1)	41 (25.9)	25 (21.6)	
Oldest sibling	69 (25.2)	48 (30.4)	21 (18.1)	
Birth weight z score, M (SD)	-0.27 (1.02)	-0.44 (0.91)	-0.042 (1.12)	0.00
Maternal Age, M (SD)	30.3 (5.8)	30.5 (6.3)	30.02 (5.2)	0.47
Maternal Education, n (%)				
≤ High school education	130 (47.4)	99(62.7)	51(44)	0.27
> High school education	144 (52.6)	59(37.3)	65(56)	
Maternal feeding behaviors[1], M (SD) Observed				
Verbal Encouragement	10.24 (8.53)	10.63 (8.94)	9.74 (7.97)	0.45
Verbal Discouragement	3.01 (4.30)	2.52 (3.45)	3.66(5.17)	0.05
Self-Reported (CFSQ)				
Verbal Direction	2.79 (0.81)	2.88 (0.78)	2.66 (0.83)	0.02
Coercion	2.12 (0.82)	2.19 (0.82)	2.03 (0.83)	0.11
Praise	3.94 (0.91)	4.03 (0.86)	3.81 (0.97)	0.06
Child eating behavior (CEBQ)[2], M (SD)				
Satiety Responsiveness	2.80 (0.64)	2.89 (0.63)	2.67 (0.63)	0.00
Slowness in Eating	2.83 (0.73)	2.89 (0.74)	2.74 (0.72)	0.09
Food Fussiness	2.70 (0.76)	2.80 (0.72)	2.58 (0.79)	0.02

[*] Table showing means (M) and standard deviations (SD) or counts (n) and percentages (%). Differences by overweight/obese status tested using t-tests for continuous variables and Chi-square tests for categorical variables.
[1] Observed maternal feeding behavior was coded from the structured eating protocol attended by each child-mother dyad.
Verbal Encouragement range= 46, Verbal Discouragement range= 27, Verbal Direction range=4, Coercion range=4, Praise range=4.
[2] Satiety Responsiveness range=4, Slowness in Eating range=4, Food Fussiness range=4.

Table 3-2[*] Differences in Maternal Feeding and Child Eating Behaviors by Birth Order

Variables	Only child	Youngest sibling	Middle sibling	Oldest sibling	P-value
Maternal feeding behavior, M (SD) Observed					
Verbal encouragement	7.93 (5.88) [a]	9.35 (7.62)	9.98 (8.15)	13.41 (10.78) [b]	0.02
Verbal discouragement	5.03 (7.46) [a]	2.68 (3.09)	3.07 (4.42)	2.27 (2.76) [b]	0.03
Self-Reported					
Verbal direction	2.82 (0.72)	2.76 (0.81)	2.73 (0.88)	2.86 (0.80)	0.81
Coercion	2.04 (0.76)	2.05 (0.79)	2.14 (0.92)	2.24 (0.81)	0.48
Praise	3.73 (0.99)	3.80 (0.82)	4.14 (0.81)	4.06 (1.03)	0.03
Child eating behavior, M (SD)					
Satiety responsiveness	2.74 (0.57)	2.89 (0.66)	2.67 (0.65)	2.82 (0.61)	0.15
Slowness in eating	2.93 (0.65)	2.90 (0.69)	2.76 (0.81)	2.74 (0.76)	0.34
Food fussiness	2.83 (0.80)	2.64 (0.80)	2.52 (0.76)	2.90 (0.62)	0.02

[*] Table showing means (M) and standard deviations (SD). Significance of differences between birth order groups tested by ANOVA.
[a,b] Discrepant letters indicate that the difference between means is statistically significant (P-value < 0.05).
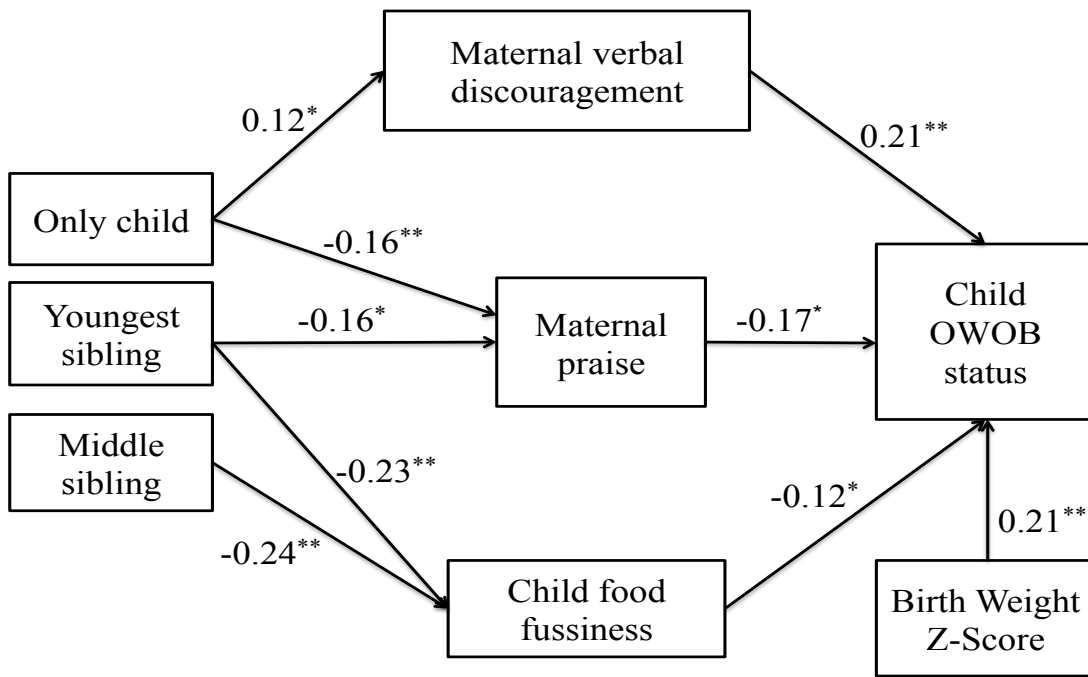
Fig. 3-1 Path model showing standardized coefficients for associations between birth order, maternal feeding behavior, child eating behavior, and child overweigh or obese status.

* $p < 0.05$

** $p \leq 0.01$

CHAPTER 4

Mealtime Behavior among Siblings and Body Mass Index of 4-8 Year Olds: A Videotaped Observational Study

Abstract

Background: Being a last-born child and having a sister have been associated with higher body mass index (BMI). Encouragement to eat that overrides children's self-regulation has been reported to increase the risk of obesogenic eating behaviors. This study sought to test the hypothesis that encouragement to eat during mealtime from older siblings and sisters mediates associations of being last-born or having a sister with higher BMI.

Method: Children aged 4-8 years (n = 75) were videotaped while eating a routine evening meal at home with one sibling present. Encouragement to eat (defined as direct prompts to eat or general positive statements about food) delivered to the index child (IC) from the sibling was coded from the videotape. Path analysis was used to examine associations between IC's birth order, sibling's sex, encouragement counts, and IC's measured BMI z-

score (BMIz).

Results: Being the younger sibling in the sibling dyad was associated with the IC receiving more encouragements to eat from the sibling (β: 0.93, 95% confidence interval (CI): 0.59, 1.26, $p<0.0001$). The IC having a sister compared with a brother was not associated with the IC receiving more encouragements to eat from the sibling (β: 0.18, 95% CI: -0.09, 0.47, $p=0.20$). The IC receiving more encouragements to eat from the sibling was associated with lower IC BMIz (β: -0.06, 95% CI: -0.12, 0.00, $p=0.05$).

Conclusions: Children were more likely to receive encouragements to eat from older siblings than younger siblings. Contrary to our hypothesis, being the recipient of encouragements to eat from a sibling was associated with lower, not higher, child BMIz, which may reflect sibling modeling of maternal behavior. Given the reported prospective associations of encouraging children to eat beyond satiety and increased obesity risk, encouragements from siblings may be a novel intervention target for obesity prevention.

Background

Family-based interventions have shown promise for childhood obesity prevention, though as with other obesity intervention strategies, effects tend to be modest (Kaplan et al., 2013). Careful examination of interaction patterns between family members that may contribute to childhood obesity risk could provide novel targets for refining and strengthening the effectiveness of family-based interventions. The family mealtime is often used as a venue for studying family interaction patterns and has also been a key focus of childhood obesity prevention programs (Moens et al., 2007; Rao, 2008; Stark et al., 2011). Most studies examining features of family mealtimes and childhood obesity have focused on mother-child interactions or the mealtime environment (Drucker et al., 1999; Fisher & Birch, 1999, 2002; Johnson & Birch, 1994; Klesges et al., 1983; Moens et al., 2007; Zeller et al., 2007). There is a lack of understanding of how siblings interact during mealtimes and how different interaction patterns relate to child body mass index (BMI).

Interactions between siblings during childhood can influence development and behavior (Dunn, 1983) through caregiving and role modeling interactions (Harrist et al., 2014; Brody et al., 1982; Dunn, 1983). During mealtimes, sibling caregiving or role modeling behaviors may be observed as encouragements to eat. Mothers encouraging children to eat has been a frequent target for obesity prevention efforts on the premise that these encouragements may be overriding the child's self-regulation of intake in response to internal satiety cues and thereby increase the risk of obesity or obesity-promoting eating behaviors (Birch & Fisher, 1998; Hughes et al., 2008; Klesges et al., 1983). We have been unable to identify any published studies examining the potential role of siblings

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encouraging a child to eat in shaping children's eating behavior and obesity risk.

The child's birth order and sex of siblings shape the nature of interactions between the siblings (Dunn, 1983). Older siblings and sisters more often act as caregivers and role models for their siblings than do younger siblings and brothers and thus may be more likely to encourage their siblings to eat (Brody et al., 1982; Dunn, 1983; Stewart & Marvin, 1984). We and others have previously reported that children who are the youngest in a sibship are more likely to be obese (Haugaard et al., 2013; Hesketh et al., 2007; Hunsberger et al., 2012; Ochiai et al., 2012) and that having a sister, compared with a brother, is associated with greater likelihood of being overweight (Mosli et al., 2015). Prior work has not yet identified a mechanism for this association (Haugaard et al., 2013; Mosli et al., 2015; Ochiai et al., 2012). The objective of this study was therefore to test the hypothesis that encouragement to eat initiated by older siblings and sisters is an underlying process for the association of being a younger sibling and having a sister with higher BMI.

Methods

Participants and Procedures

The study sample includes 301 child-mother dyads that were recruited through Head Start programs in South Central Michigan for a study about feeding behaviors (full study sample described in Chapter 1, "Study Population"). For this analysis we only included children who were living with their biological mothers (as this represents the majority of this sample), who were living with only one sibling, and who had complete data on all variables (n= 102). Of those 102 children, we only included index children whose siblings were at least a year old (n=86) on the premise that the processes via which

infants may influence eating behavior of siblings could be fundamentally different. Mothers provided written informed consent for themselves and for their children. The University of Michigan Institutional Review Board approved this study.

During 2 study visits, mothers completed questionnaires, and trained staff members obtained child anthropometry. Three videotaped home mealtime observations were completed for each family. Each mother was asked to record three routine evening meals within a single week. Research assistants called each mother after the meal to obtain information regarding individuals present. These family mealtime observations (FMOs) followed standard procedures that have been previously described (Goulding et al., 2014).

For the present study, inclusion criteria for the FMO videotape included that the index child (IC) was eating with his/her sibling, and that the IC was not eating with other children in addition to the sibling. We systematically selected one of the three FMO videos for each IC. We started video selection with the second FMO video on the premise that we would expect families to be more acclimated to the camera by the second home observation. If the second FMO video did not meet the inclusion criteria, we then assessed the third FMO video; if the third FMO video did not meet inclusion criteria, we assessed the first FMO video. After assessment of the FMO videos for each IC, a final sample of 75 index children was identified (8 from the first FMO, 55 from the second FMO, and 12 from the third FMO). The sample included in this analysis (n = 75) did not differ from the sample not included (n = 226) with regard to child sex, child race/ethnicity, birth weight z-score, and maternal age.

Measures

Demographic Characteristics

Mothers reported information regarding IC's birthdate, sex, and race/ethnicity
(dichotomized for this report as non-Hispanic white vs. not) and mother's birthdate and
years of education (dichotomized as more than or equal to a high school education vs. not).
Birthdates and dates of visits were used to calculate child and maternal age.

Sibling Characteristics and Birth Order

For each individual living in the household, as well as for each individual on the
FMO videotapes, mothers reported age, sex, and relationship to the IC. This information
was used to determine the IC's birth order (i.e., younger sibling vs. older sibling) and
characteristics of the siblings.

Coding of Interactions between Index Child and Sibling

To evaluate mealtime sibling behaviors that may be most relevant to child obesity
risk, we developed a coding scheme based on Bob and Tom's Method of Assessing
Nutrition (BATMAN)(Klesges et al., 1983). The BATMAN is an observational assessment
used to evaluate parental behavior around food (Klesges et al., 1983). Although restrictive
feeding behaviors are part of the BATMAN, we did not code these behaviors as they were
not observed to occur between siblings with meaningful frequency. Although the
BATMAN distinguishes between physical and verbal encouragements to eat, we did not
observe frequent physical encouragements to eat between siblings and therefore focused
our coding scheme on verbal encouragements to eat. The BATMAN defines verbal
encouragements to eat as suggesting, demanding, directing, and making positive

statements about food. We adapted some of the operational definitions to be consistent with theoretically important features of sibling interactions (i.e., parent-like interactions or "complementarity" and peer-like interactions or "reciprocity") (Harrist et al., 2014; Dunn, 1983). For example, food offers (representing complementarity) and statements about eating/finishing the food (representing reciprocity) were each counted as verbal encouragements to eat. The coding manual is shown in Appendix C.

Encouragements to eat delivered by the sibling and directed to the IC were coded in 5-minute intervals from the videos. Ten percent of the videos were double coded and inter-rater reliability by intraclass correlation coefficient exceeded 0.80. Number of encouragements was summed across intervals to create the variable "total encouragements delivered to IC by sibling".

Mealtime Maternal Presence

Siblings interact differently when their mother is present (Corter, Abramovitch, & Pepler, 1983; Lamb, 1978). In order to adjust for maternal presence, we coded whether the mother was sitting with the siblings during the meal in each 5-minute interval (yes vs. no for each interval). Inter-rater reliability computed as Cohen's kappa was 1.00. We created the variable "proportion of intervals in which mother is present" by dividing the total number of intervals in which the mother was sitting with the siblings by the total number of intervals.

Anthropometry

Staff members measured index children's weight and height during study visits using standardized procedures. BMI was calculated and age and sex specific BMI z-score

(BMIz) for the IC was calculated based on the US Centers for Disease Control and Prevention reference growth curves (Ogden, 2010). Mothers reported the IC's birth weight, which was converted to z-scores based on National Centers for Health Statistics Natality Datasets (Oken et al., 2003). Birth weight z-scores were missing and were imputed for 26 subjects using multiple imputation.

Statistical Analysis

We conducted statistical analysis using Stata version 13 (StataCorp. 2013. *Stata Statistical Software: Release 13*. College Station, TX: StataCorp LP). First, we calculated descriptive statistics for sample characteristics. Then, to test our hypothesis that encouragements to eat from the sibling is a mediating variable in the association of IC's birth order and the sibling's sex with IC's BMIz, we conducted path analysis, which is an extension of the regression model comprised only of directly observed variables (Acock, 2013). We ran our path model testing associations between IC's birth order, the sibling's sex, encouragements to eat directed to the IC from the sibling, and IC's BMIz. We included the binary variables IC's birth order (with "older sibling" as the reference category) and sibling's sex (with "male" as the reference category) as predictors in the model. A Poisson distribution was used to model the mediating count variable "total encouragements delivered to IC from sibling", and "number of meal intervals" was set as the offset variable to account for variations in length of the meal. The model was adjusted for maternal presence (i.e., proportion of intervals in which mother is present), sibling's age, and the IC's birth weight z-score. For all statistical analyses, significance level was set at 0.05.

Results

Mean IC age was 5.3 years (± SD 0.8), and about half (50.70%) were male (Table 4-1). Path analysis showed that the IC being the younger sibling in the dyad, as opposed to the older sibling, was associated with receiving more encouragements to eat from the sibling (β: 0.93, 95% CI: 0.59, 1.26, *p*<0.0001). The IC having a sister as opposed to a brother was not directly associated with the IC receiving more encouragements to eat from the sibling (β: 0.18, 95% CI: -0.09, 0.47, *p*=0.20). The IC receiving more encouragements to eat from the sibling was associated with lower IC BMIz (β: -0.06, 95% CI: -0.12, 0.00, *p*=0.05). There was a marginally significant direct positive association between the IC being the younger sibling in the sibling dyad and the IC's BMIz (β: 0.81, 95% CI: -0.82, 1.70, *p*=0.08). There was no direct association of the IC having a sister, as opposed to a brother, with the IC's BMIz (β: 0.27, 95% CI: -0.17, 0.72, *p*=0.23) (Figure 4-1).

Discussion

Findings from this study did not support our hypothesized conceptual model that receiving more encouragements to eat from a sibling is an underlying process for the association between having an older sibling or a sister with higher child BMIz. However, our results do provide support for our hypothesis that siblings play an important role in the family mealtime environment.

Our study suggests that birth order is associated with the number of encouragements a child receives from his/her sibling, with younger siblings receiving more encouragements to eat from their older siblings. We did not detect a statistically significant association between having a sister and receiving more encouragements to eat, though the

direction of association was in the expected direction. In summary, in consensus with some of the available literature on sibling interactions in other domains, we found that older siblings may act as potent caregivers and role models during mealtimes (Brody et al., 1982; Dunn, 1983; Stewart & Marvin, 1984). These novel findings regarding how siblings interact around food may contribute to better understanding of how families function during mealtimes.

Contrary to our hypothesis that encouragements to eat directed to the IC from the sibling would be positively associated with the IC's BMIz, we found that encouragements to eat directed to the IC from the sibling was associated with the IC having a lower BMIz. We had based our hypothesis on reports that encouragement to eat from mother to child was positively associated with child overweight (Birch & Fisher, 1998; Hughes et al., 2008; Klesges et al., 1983). However, others have reported that controlling maternal feeding practices (including encouragement to eat) are inversely associated with child BMI (Galloway, Fiorito, Francis, & Birch, 2006; Powers, Chamberlin, Schaick, Sherman, & Whitaker, 2006; Robinson, Kiernan, Matheson, & Haydel, 2001). It is thus not fully understood whether controlling feeding behaviors and encouragements to eat by parents are associated with lower concurrent BMI, or whether they may predict increases in BMI prospectively (Faith et al., 2004; Fisher & Birch, 1999, 2002; Johnson & Birch, 1994; Robinson et al., 2001). Since mothers may encourage children who are perceived to be thinner or have a poorer appetite to eat more (Powers et al., 2006), it is plausible that this kind of feeding behavior might over time reduce the child's ability to self-regulate intake in response to satiety cues and eventually lead to excessive weight gain (Fisher & Birch,

1999, 2002; Johnson & Birch, 1994). Whether or not this is the case with regard to the association between encouragements from siblings and child BMI is unknown. However, our data suggest that cross-sectionally, older siblings may be imitating their mothers and encouraging siblings who are thinner to eat more. Prospective studies are needed to better establish the direction of this association.

Strengths of this study include the use of an observational assessment of interactions between siblings during a naturalistic mealtime setting. Limitations of this study include the small sample size, which might have restricted our ability to detect significant associations. Generalizability of our findings may be limited, given that the study cohort only included low-income Head Start families. Furthermore, the study design does not allow us to infer causality or test whether associations may be bidirectional.

Conclusion

Including multiple family members in child obesity programs can be associated with more positive outcomes (Kaplan et al., 2013); including siblings as part of family-based programs represents a novel approach. Future studies are needed to further explore the role of siblings in feeding and the effect of including them in obesity prevention interventions.

Table 4-1* Sample Characteristics

	Total n= 75
Index child age, M(SD)	5.33 (0.79)
Index child sex, n (%) Male Female	38 (50.70) 37 (49.30)
Index child race/ethnicity, n (%) Non-Hispanic white Hispanic or not white	44 (58.70) 31 (41.30)
Maternal age, M (SD)	30.85 (6.73)
Maternal education, n (%) ≤ High school education > High school education	31 (41.3) 44 (58.7)
Sibling age, M (SD)	6.14 (3.49)
Sibling sex, n (%) Male Female	37 (49.3) 38 (50.7)
Index child birth order, n (%) Younger sibling Older sibling	41 (54.7) 34 (45.3)
Total encouragements delivered to index child from sibling, M(SD)	2.81 (3.93)
Proportion of intervals in which mother is present, M(SD)	0.86 (0.30)
Index child BMI z-score, M(SD)	0.81 (1.08)
Index child birth weight z-score, M(SD)	-0.22 (1.03)

* Table showing means (M) and standard deviations (SD) or counts (n) and percentages (%).
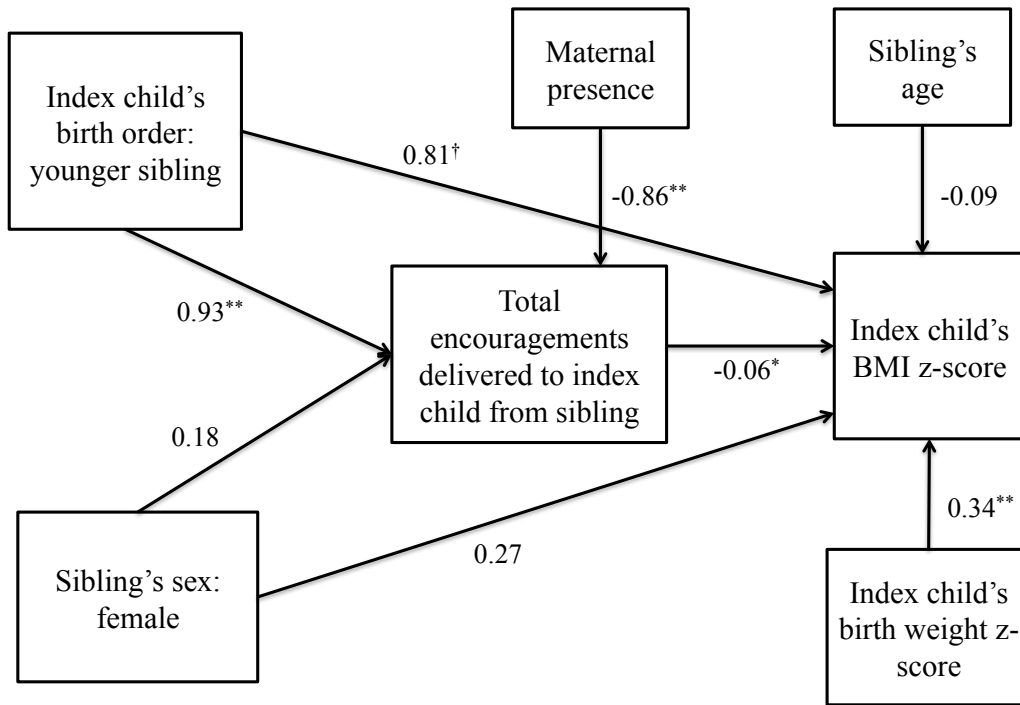
Figure 4-1. Path model showing path coefficients for associations between index child's birth order, sibling's sex, total encouragements delivered to index child from sibling, and index child's BMI z-score.

* $p \leq 0.05$

** $p \leq 0.01$

† $p \leq 0.1$

CHAPTER 5

Conclusions

Summary and Implications of Dissertation Findings

Siblings are an integral part of an individual's life, particularly during childhood. Their role in influencing various developmental outcomes is widely recognized (Brody, 2004; Downey, Condron, & Yucel, 2015; Dunn & Robert Plomin, 1991; Stocker et al., 1989; Volling, 2012). Understanding the role of siblings in influencing child weight status is needed for designing effective family-based programs aiming to help lower childhood obesity rates. The objective of this dissertation was to examine the associations between sibship composition, mealtime behaviors and child weight status. The study sample used in this research included high-risk, low-income children who had a high prevalence of overweight and obesity. Moreover, data used was a rich resource for characterizing sibship composition, maternal, child, and household features, as well as reported and observed mealtime behaviors.

Findings of our study described in Chapter 2 support our hypothesis that sibship composition is associated with child weight status. We found that only children and youngest siblings are more likely to be overweight or obese. Additionally, we found that having younger siblings and a brother was associated with lower odds of overweight or

obesity. Including non-biological siblings in the analysis did not change the associations. Adjusting for a number of potential intermediate variables, including maternal relationship status, household food insecurity, maternal depression symptoms, maternal BMI and child birth weight z-score, did not attenuate the associations between sibling variables and child weight status. This suggests that the underlying pathways may be other than these child, maternal, and household characteristics.

In Chapter 3, we sought to identify the underlying behavioral pathways of association between birth order and child overweight or obesity. We examined observed and reported maternal feeding practices as well as child eating behaviors as potential mediators. Our findings support our hypotheses that higher maternal restriction and lower maternal support during mealtimes is an underlying pathway for the association between only child status and overweight or obesity, and that lower maternal support and child food acceptance during mealtimes is an underlying pathway for the association between youngest sibling status and overweight or obesity.

In addition to parenting behavior, direct sibling interaction is another underlying pathway for associations with developmental outcomes among children who have siblings (Brody, 2004; Dunn, 1983). In Chapter 4, we evaluated interactions between sibling pairs in the context of mealtimes as an underlying process for the associations of birth order and sibling's sex with child BMI z-score. Our findings did not support our hypothesized conceptual model that receiving more encouragements to eat from a sibling is an underlying process for the association between having an older sibling or a sister with higher child BMI z-score. However, our study results suggest that older siblings play an

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important role during mealtimes, where they appear to act as caregivers and role models for their younger siblings by encouraging them to eat. Although encouragements to eat from older siblings was associated with lower BMI z-score of younger siblings, this association is cross-sectional and the prospective effect on child weight status is unknown.

Given the shift seen in the average family size in the US and the increase in the number of children growing up without other children in the household (Vespa et al., 2013), considering associations between sibship composition and obesity risk when counseling families as part of management and prevention programs is especially important. This dissertation provides evidence that only children, youngest siblings, and children who do not have brothers are more likely to be overweight or obese. Thus, children with these characteristics may be considered as key candidates for obesity prevention interventions. Our findings suggest a novel approach for future intervention studies that examine the effect of including both mothers and siblings in intervention programs. Future studies may focus on counseling mothers of only children and youngest siblings on feeding practices during mealtimes; appropriate control and support may be discussed. Mothers of youngest siblings may be made aware that their children may be more accepting of different types of food, and thus being especially mindful of types of foods available may be beneficial. Furthermore, this work suggests that older siblings, who may act as caregivers and role models during mealtimes, may be educated on healthy eating behaviors, including healthy food choices and appropriate portion sizes for different age groups. Since we observed that thinner children might receive more encouragements to eat from their siblings, prevention efforts may also focus on counseling siblings on healthy

child weight status and growth trajectories. Mothers are influential in shaping sibling interactions (Kramer, 2004). Therefore, they may be educated on how to encourage sibling mealtime interactions that can promote healthy eating behaviors, such as facilitating discussions that are not related to food.

Possible Future Directions

This dissertation helps address several gaps in the existing literature. Due to the comprehensive data on family and household characteristics of participants in our study, we were able to accurately define sibship composition and birth order categories (e.g., selecting only children and oldest siblings in separate groups) and to account for potential confounders and intermediate variables. We were also uniquely positioned to examine both observed and reported maternal feeding practices as underlying pathways of association. Furthermore, we were the first to report an evaluation of sibling interactions during a naturalistic mealtime setting.

However, this work has several limitations that can be addressed in future research. First and foremost, studies described in this dissertation are cross-sectional and cannot test causality. While it is not realistic to perform intervention studies with manipulation of sibship composition, longitudinal studies can establish temporality of events, and thus can support the existence of causal associations. Future studies that monitor families before and after the birth of a new sibling may be helpful. Such studies can monitor both changes in weight status of index children as well as changes in the behavior of family members that may explain these associations. Furthermore, our sample size was relatively small, which might have affected our ability to detect significant associations. Future studies that

include larger sample sizes are warranted. Our sample also consisted of low-income families recruited through Head Start, and thus our findings may not be generalizable to families from other socioeconomic stratus backgrounds. A nationally representative sample may provide higher external validity.

Findings from this dissertation can serve as an initial step for future studies aiming to expand our understanding of how the family system relates to child weight status. This research focused on examining the behavior of subsystems (i.e., mother-child dyads, sibling dyads) as pathways for associations with child weight status. However, studying additional subsystems (i.e., father-mother and father-child dyads) and the family as a whole might be important for eliciting behavior change for obesity prevention (Skelton, Buehler, Irby, & Grzywacz., 2012). A family as a whole generally seeks a state of equilibrium; which is achieved by maintaining a set of established roles and interaction patterns (Bavelas & Segal, 1982; Broderick, 1993; Skelton et al., 2012). A change in a specific behavior might require a change in related interaction patterns that have been essential in maintaining equilibrium. Future research aiming to study the family as a whole and its association with child weight status can include fathers in addition to siblings and mothers. Qualitative research involving in depth interviewing with mothers and fathers can help detect differential parenting practices among siblings. Observational coding of the family as a whole during mealtimes can also expand our understanding of factors that modify interactions between siblings and between siblings and parents. Finally, although our studies only examined weight status outcomes of the index child, future studies can additionally examine weight status outcomes among siblings within each family.

Overall, this dissertation provides interesting findings regarding relationships between sibship composition, mealtime behaviors and child weight status. Evidence from this research can inform future studies aiming to further establish these associations and family-based programs aiming to help lower childhood obesity rates.

APPENDICES

Appendix A

Caregiver's Feeding Styles Questionnaire (CFSQ)

	These questions deal with __YOUR__ interactions with your preschool child during the dinner meal. Circle the best answer that describes how often these things happen. If you are not certain, make your best guess. *How often during the dinner meal do YOU….*	Never	Rarely	Some times	Most of the Time	Always
1.	Physically struggle with the child to get him or her to eat (for example, physically putting the child in the chair so he or she will eat).	1	2	3	4	5
2.	Promise the child something other than food if he or she eats (for example, "If you eat your beans, we can play ball after dinner").	1	2	3	4	5
3.	Encourage the child to eat by arranging the food to make it more interesting (for example, making smiley faces on the pancakes).	1	2	3	4	5
4.	Ask the child questions about the food during dinner.	1	2	3	4	5
5.	Tell the child to eat at least a little bit of food on his or her plate.	1	2	3	4	5
6.	Reason with the child to get him or her to eat (for example, "Milk is good for your health because it will make you strong").	1	2	3	4	5
7.	Say something to show your disapproval of the child for not eating dinner.	1	2	3	4	5
8.	Allow the child to choose the foods he or she wants to eat for dinner from foods already prepared.	1	2	3	4	5
9.	Compliment the child for eating food (for example, "What a good boy! You're eating your beans").	1	2	3	4	5
10.	Suggest to the child that he or she eats dinner, for example by saying, "Your dinner is getting cold".	1	2	3	4	5
11.	Say to the child "Hurry up and eat your food".	1	2	3	4	5

12.	Warn the child that you will take away something **other than food** if he or she doesn't eat (for example, "If you don't finish your meat, there will be no play time after dinner").	1	2	3	4	5
13.	Tell the child to eat something on the plate (for example, "Eat your beans").	1	2	3	4	5
14.	Warn the child that you will take a food away if the child doesn't eat (for example, "If you don't finish your vegetables, you won't get fruit").	1	2	3	4	5
15.	Say something positive about the food the child is eating during dinner.	1	2	3	4	5
16.	Spoon-feed the child to get him or her to eat dinner	1	2	3	4	5
17.	Help the child to eat dinner (for example, cutting the food into smaller pieces).	1	2	3	4	5
18.	Encourage the child to eat something by using food as a reward (for example, "If you finish your vegetables, you will get some fruit").	1	2	3	4	5
19.	Beg the child to eat dinner.	1	2	3	4	5

Appendix B

Children's Eating Behavior Questionnaire (CEBQ)

Please read the following statements and tick the boxes most appropriate to your child's eating behavior.

	Never	Rarely	Some-times	Often	Always
My child loves food	□	□	□	□	□
My child eats more when worried	□	□	□	□	□
My child has a big appetite	□	□	□	□	□
My child finishes his/her meal quickly	□	□	□	□	□
My child is interested in food	□	□	□	□	□
My child is always asking for a drink	□	□	□	□	□
My child refuses new foods at first	□	□	□	□	□
My child eats slowly	□	□	□	□	□
My child eats less when angry	□	□	□	□	□
My child enjoys tasting new foods	□	□	□	□	□
My child eats less when s/he is tired	□	□	□	□	□
My child is always asking for food	□	□	□	□	□
My child eats more when annoyed	□	□	□	□	□
If allowed to, my child would eat too much	□	□	□	□	□
My child eats more when anxious	□	□	□	□	□
My child enjoys a wide variety of foods	□	□	□	□	□
My child leaves food on his/her plate at the end of a meal	□	□	□	□	□
My child takes more than 30 minutes to finish a meal	□	□	□	□	□

	Never	Rarely	Some-times	Often	Always
Given the choice, my child would eat most of the time	□	□	□	□	□
My child looks forward to mealtimes	□	□	□	□	□
My child gets full before his/her meal is finished	□	□	□	□	□
My child enjoys eating	□	□	□	□	□
My child eats more when she is happy	□	□	□	□	□
My child is difficult to please with meals	□	□	□	□	□
My child eats less when upset	□	□	□	□	□
My child gets full up easily	□	□	□	□	□
My child eats more when s/he has nothing else to do	□	□	□	□	□
Even if my child is full up s/he finds room to eat his/her favourite food	□	□	□	□	□
If given the chance, my child would drink continuously throughout the day	□	□	□	□	□
My child cannot eat a meal if s/he has had a snack just before	□	□	□	□	□
If given the chance, my child would always be having a drink	□	□	□	□	□
My child is interested in tasting food s/he hasn't tasted before	□	□	□	□	□
My child decides that s/he doesn't like a food, even without tasting it	□	□	□	□	□
If given the chance, my child would always have food in his/her mouth	□	□	□	□	□
My child eats more and more slowly during the course of a meal	□	□	□	□	□

Coding Manual

This coding manual was based on definitions of coding categories described in Bob and Tom's Method of Assessing Nutrition (BATMAN) developed by Klesges and colegues.

Instructions for using the coding manual:

1- Open the FMO Coding Sheet Template, and Save As a new document. Please do not make any changes to the template.

2- Open the FMO Coding Manual and follow the directions on how to properly fill out the coding sheet.

3- We code in 5-minute intervals. Begin coding <u>the instant the index child appears on the tape and sits down for the first time to eat</u>. Pause the video and enter the time into the coding sheet. The rest of the cells will automatically populate with the correct times.

4- Indicate in the "index child" column who the index child is (e.g. younger boy wearing red shirt).

5- Indicate in the "sibling" column who the sibling is (e.g. older girl wearing yellow dress).

6- Stop coding if/when one of the siblings is <u>no longer present</u> (i.e. if the sibling leaves the table and you can no longer <u>see or hear</u> him/her for the rest of the video). You must watch the rest of the video to determine this.

Verbal Encouragement-Direct Prompts	Count the number of times child **prompts his/her sibling to eat.** Mark this by entering "1" then "2" then "3" etc. on the coding sheet in the appropriate interval when the child prompts his/her sibling to eat. Prompts about water should NOT be coded.
	
	1- Commanding, directing and suggesting: These include statements that are directly related to food or to actions that facilitate eating (e.g. sitting down to eat)
	    ▪ "Eat your food"
	    ▪ "Here have some"
	    ▪ "You have to come sit down"
	
	2- Food offer: Each time the child verbally offers his/her sibling food, count it as verbal encouragement.
	    • "Do you want some X?" or "Want some X?"

Verbal Encouragement-General Statements	Count the number of times child makes **general positive statements about food or about eating/finishing the food.** Mark this by entering "1" then "2" then "3" etc. on the coding sheet in the appropriate interval. Statements about water should NOT be coded.
	
	1- Positive statements about food: when the child says something **obviously positive about the food** or makes **sounds of enjoyment** (e.g. Mmmm…) count as verbal encouragement.
	Some comments about the food are just considered "talk about food" and are NOT a prompt to eat. For example, "These are green beans" is just a comment about the food. However, "Mmm, good green beans!" is verbal encouragement to eat.
	
	- The food that the general statement is referring to must be **available to the siblings** (i.e. part of the meal) in order for it to count. For example, if a child says "strawberries are yummy" but there are no strawberries available at the dinner table, this does not count as verbal encouragement.
	
	2- Statements about eating/finishing food: Each time the child makes a statement about eating/ finishing the food, count as verbal encouragement.
	    ▪ "I am eating mine"
	    ▪ "I ate all of mine"
	    ▪ "I'm going to get some more"
	    ▪ "I'm dipping mine in ketchup

	- Statements of verbal encouragements from the child do not have to be directly said to the sibling. However, the sibling MUST BE PRESENT in order for it to count. - Food requests from the <u>sibling</u> or the <u>parent</u> DO NOT count as statements of verbal encouragements. - "I'm done" does NOT count as a general statement of verbal encouragement - Statements that are in response to a <u>question or a prompt</u> (e.g. responding to the mother asking "how's the food?" or "eat you food") should NOT be considered verbal encouragement. However, if the mother or another person at the table <u>comments</u> about the food (e.g. "these are good") and the index child or the sibling <u>voluntarily responds</u> by a positive statement about the food or about eating the food (e.g. "I'm finishing all of mine"), this counts as a general statement of verbal encouragement.
Parental Presence	• For each 5-minute interval, please enter 1 if mother figure is sitting with siblings and 0 if not. Enter 1 if father figure is sitting with siblings and 0 if not. • Mother/father figure sitting with siblings: Mother/father figure must be close to the siblings so that they can easily engage in conversations and make eye contact with them (e.g. sitting with siblings at dinner table). Mother/father figure does not have to be eating while sitting down. If the mother/father figure is eating while standing right next to the siblings, he/she is considered to be "sitting with siblings". If it is not possible to tell whether or not the mother/ father figure is sitting with the siblings (due to positioning of the camera), please enter "9".

Appendix D

Maternal Behavior as a Predictor of Sibling Interactions During Mealtimes

Abstract

Cues to eat are associated with obesity risk among children. During family mealtimes, cues to eat can occur between siblings in the form of verbal encouragements to eat. Since mothers are influential in shaping sibling interactions in other domains, this study aimed to examine the associations of maternal presence and maternal engagement with children during mealtimes with encouragements to eat delivered by the child to his/her sibling. Children aged 4-8 years (n = 73) were videotaped while eating a routine evening meal at home with one sibling present. Encouragement to eat delivered by the index child to the sibling, maternal presence, and non food-related and food-related maternal engagement were coded from the videotapes. Poisson regression showed that maternal presence was associated with fewer encouragements to eat from the index child to the sibling (rate ratio (RR): 0.40, 95% confidence interval (CI): 0.26, 0.62). Each type of maternal engagement was independently associated with the number of encouragements to eat from the index child to the sibling: maternal engagement that was not food-related was associated with fewer encouragements to eat (RR: 0.62, 95% CI: 0.53, 0.73), while maternal engagement that was food-related was associated with more encouragements to eat (RR: 1.49, 95% CI: 1.22, 1.81). These findings suggest that mothers may play an important role in shaping sibling food-related interactions during mealtimes. Future obesity

prevention interventions may focus on counseling mothers on how to improve siblings'

food-related interactions.

Background

Childhood obesity continues to be a major public health concern (Ogden et al., 2014) and effective interventions are needed. Frequent family mealtimes have been found to be associated with healthier eating habits and lower obesity risk among children (Carnell & Wardle, 2008; Hammons & Fiese, 2011). However, specific features of family mealtimes that may help enhance intervention outcomes are not well characterized.

The family mealtime is an environment in which children receive cues to eat. Receiving more cues to eat is linked with higher obesity risk (Polivy & Herman, 2014). Furthermore, a heightened sensitivity to cues to eat may contribute to excessive weight gain in some individuals (Carnell & Wardle, 2008). Reducing the number and intensity of cues to eat can lead to a greater decline in body mass index among overweight and obese children (Epstein et al., 2008). In the context of family mealtimes, cues to eat can be in the form of either direct prompts or positive statements about food (i.e., encouragements to eat). There is variability between families in the intensity and frequency of encouragements to eat (Klesges et al., 1983). Identifying features of family mealtimes that are associated with these types of cues to eat can help inform intervention strategies.

Mothers encouraging children to eat beyond satiety has been linked with increased obesity risk (Birch & Fisher, 1998; Klesges et al., 1983), but siblings may deliver many of the encouragements to eat that occur during mealtimes. Given that it is well recognized that mothers influence the level and type of sibling interactions (Corter et al., 1983), one approach to optimizing family mealtimes as an obesity prevention venue is to help mothers

shape sibling food-related interactions. We were unable to identify studies that examined how mothers shape sibling food-related interactions at mealtimes.

In the present study we conceptualized maternal behavior during mealtime in three ways; first, we considered whether the mother sat with the children or not. Secondly, we considered the degree to which the mother engaged with the children about topics not related to food. Thirdly, we considered the degree to which the mother engaged with the children about topics related to food. Given prior literature indicating that there is less sibling interaction when mothers are present (Corter et al., 1983), we hypothesized that the mother sitting with the children during mealtime would be associated with fewer encouragements to eat delivered by one sibling to another. In addition, given that mothers shape the content of sibling conversations (Howe, Fiorentino, & Gariépy, 2003), we hypothesized that maternal engagement with the children that was not food-related would be associated with fewer encouragements to eat delivered by one sibling to another. Conversely, we hypothesized that maternal engagement with the children that was food-related would be associated with more encouragements to eat delivered by one sibling to another.

Methods

Participants and Procedures

The original cohort included 301 mother-child dyads recruited through Head Start programs to participate in a study about feeding behaviors. At the time of this follow-up study, the children included in these dyads (i.e., index children) were between the ages of 4 and 8 years. Inclusion and exclusion criteria were described elsewhere (Mosli et al., 2015).

Mothers reported index child, age, sex and race/ethnicity, and family composition, including the age and sex of each individual living in the household and their relationship to the index child. Mothers were asked to video record 3 of the index child's routine evening meals within a single week. These mealtime observations followed standardized procedures that have been described previously (Goulding et al., 2014).

For this analysis, we included only index children who had complete data on all variables; who were living with their biological mothers; who were living with only one sibling; whose siblings were at least 12 months old; and who had at least one mealtime observation video on which they were eating with their sibling without the presence of any additional children.

Only one mealtime observation video per index child was selected to code mealtime behaviors. The second mealtime observation was chosen preferentially on the premise that families may be more acclimated to the camera by the second observation. If the second mealtime observation video did not meet inclusion criteria (i.e., the index child was not eating with the sibling or additional children were present), the third and then first videos were considered. Therefore, of the videos selected, 53 were of the first mealtime observation, 12 were of the third, and 8 were of the first.

The final sample included in this analysis (n = 73) did not differ from the sample not included (n = 228) with regard to child sex, child race/ethnicity, and maternal age. The University of Michigan Institutional Review Board approved this study.

Measures

Encouragement to Eat

The number of encouragements to eat, including direct prompts and positive statements about food, delivered from the index child to his/her sibling (Klesges et al., 1983), were counted in 5-minute intervals. Inter-rater reliability was high for the subsample of 10% of videos that were double coded (intraclass correlation coefficient (ICC) > 0.80).

Maternal Presence and Engagement

Whether or not the mother sat with the siblings during the meal was coded in each 5-minute interval (yes vs. no for each interval; inter-rater reliability by Cohen's κ = 1.00). The variable "maternal presence" was defined as the proportion of the mealtime during which the mother sat with the siblings (potential range 0 to 1).

Two types of mother's engagement with the index child during the meal (non food-related and food-related engagement) were rated on a scale from 0 (the mother was not seen or heard on the video) to 5 (the mother was deeply engaged) for each 5-minute interval (inter-rater reliability ICC > 0.80 for each). Non food-related engagement was defined as the intensity of mother's engagement with the child in general throughout the meal. This included any positive or negative, verbal or non-verbal interaction that was not related to the food being served or the child's eating behavior (e.g., discussing daily activities, hugging, eye contact). Food-related engagement was defined as the intensity of mother's engagement with the child's eating behavior throughout the meal (e.g., discussing what or how the child is eating). This included any positive or negative, verbal or non-verbal interaction that was related only to the food being served or the child's eating behavior. The variables "maternal engagement with index child: not food-related" and

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"maternal engagement with index child: food-related" were each calculated as the mean of the ratings across time intervals during the meal.

Statistical Analysis

Analyses were conducted using IBM SPSS Statistics 21.0 (Armonk, NY, USA). Descriptive statistics were calculated to assess sample characteristics. Poisson regression was used to test two models: (1) "maternal presence" as the predictor of "total encouragements from the index child to the sibling" and (2) "maternal engagement with index child: not food-related" and "maternal engagement with index child: food-related" as predictors of "total encouragements from the index child to the sibling". In both models "number of intervals" was set as the offset variable in Poisson regression to account for variations in length of the meal. Since preliminary analyses did not reveal any evidence of confounding, and given our small sample size, regression models were not adjusted for any covariates. Specifically, analyses showed that maternal presence and maternal engagement were not associated with index child age, index child race/ethnicity, and sibling age.

Results

Characteristics of the total sample are shown in Table D-1. As shown in Table D-2, each unit increase in maternal presence was associated with a 60% decrease in the number of encouragements to eat from the index child to the sibling (rate ratio (RR): 0.40, 95% confidence interval (CI): 0.26, 0.62). Each unit increase in maternal engagement with the index child that was not food-related was associated with a 38% decrease in the number of encouragements to eat from the index child to the sibling (RR: 0.62, 95% CI: 0.53, 0.73). Conversely, each unit increase in maternal engagement with the index child that was food-

related was associated with a 49% increase in the number of encouragements to eat from the index child to the sibling (RR: 1.49, 95% CI: 1.22, 1.81).

Discussion

This study found that maternal presence, as well as maternal engagement with the index child that was not food-related, were each associated with fewer encouragements to eat from the index child to the sibling. In contrast, maternal engagement with the index child that was food-related was associated with more encouragements to eat from the index child to the sibling. These findings are of interest in the context of prior work reporting that a greater number of adults present during mealtimes is associated with a lower prevalence of obesity among children (Jacobs & Fiese, 2007); our results suggest the possibility that one underlying mechanism of association may be the manner by which adults alter sibling interactions during mealtimes.

Mothers are key participants in interventions aimed at improving family functioning (Kramer, 2004). Future studies might examine the role of mothers in driving family mealtime conversations and interactions. Since obese children are especially sensitive to food cues (Polivy & Herman, 2014), reducing the number of encouragements to eat that occur during family mealtimes may be beneficial. For example, mothers may be encouraged to be present during mealtimes and to facilitate discussions about non food-related topics (e.g., school events or activities) rather than topics that focus on food.

Strengths of this study include our use of observational assessment during a naturalistic mealtime. Limitations include the cross-sectional design, which limits the ability to infer causality. The small sample size may also have limited the power to detect

associations. In addition, we did not adjust for potential confounders in our analysis, and we cannot rule out residual confounding by characteristics that were not accounted for, such as the weight status of the siblings and the mother. The study findings may not be generalizable to families who are not low-income or children who are not Head Start graduates. Finally, our study did not include a direct measure of the amount of food eaten by children during mealtime. Future studies may examine changes in the child's eating behavior in response to maternal and sibling behavior.

In conclusion, these findings may provide a novel strategy for interventions targeting family mealtimes as a venue for obesity prevention. Specifically, it might be important not only to guide mothers' interactions with the individual child at risk of obesity, but also to guide mothers in shaping sibling food-related interactions.

Table D-1.[*] Sample Characteristics

Variable	Total n = 73
Index child age in years, M(SD)	5.33 (0.80)

Index child sex, n (%)
    Male
    Female
	
	37 (50.7)
	36 (49.3)

Index child race/ethnicity, n (%)
    Non-Hispanic white
    Hispanic or not white
	
	43 (58.9)
	30 (41.1)

Sibling age in years, M(SD)	6.17 (3.50)

Sibling sex, n (%)
    Male
    Female
	
	36 (49.3)
	37 (50.7)

Total encouragements from the index child to the sibling, M(SD)	3.23 (3.89)
Maternal presence, M(SD)	0.86 (0.30)
Maternal engagement with index child: not food-related, M(SD)	3.00 (1.00)
Maternal engagement with index child: food-related, M(SD)	2.75 (0.98)

[*] Table showing means (M) and standard deviations (SD) or counts (n) and percentages (%).

Table D-2. Associations of Maternal Presence and Maternal Engagement with Total
Encouragements From the Index Child to the Sibling

	Total encouragements delivered by the index child to the sibling RR (95% CI) n=73
Maternal presence	0.40 (0.26, 0.62)[**]
Maternal engagement with index child: not food-related Maternal engagement with index child: food-related	0.62 (0.53, 0.73)[**] 1.49 (1.22, 1.81)[**]

** P-value <0.01

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