THE EFFECT OF INFANT FEEDING ON CHILDHOOD BODY COMPOSITION

BY

Karla Wessling

Submitted to the graduate degree program in Dietetics and Nutrition and the Graduate Faculty of the University of Kansas in partial fulfillment of the requirements for the degree of Master of Science.

Committee Chair: ______________________________

Susan E. Carlson, Ph.D

Committee Members: ______________________________

Holly Hull, Ph.D

____

Elizabeth Kerling, MS, RD, LD

Date Defended: March 26th 2014

The Thesis Committee for Karla Wessling certifies that this is the approved version of the following thesis:

THE EFFECT OF INFANT FEEDING PRACTICES ON CHILDHOOD BODY COMPOSITION

Committee Chair: ______________________________

Susan E. Carlson, Ph.D

Date Approved: April 21st 2014

Abstract

Childhood overweight and obesity has been increasing in the United States. According to the 2009-2010 National Health and Nutrition Examination Survey (NHANES), almost one third of children and adolescents in America are either overweight or obese. Overweight is defined as at or above the 85^{th} percentile and less than the 95^{th} percentile on the Center for Disease Control and prevention (CDC) BMI-for-age growth charts. Obesity is defined as at or above the 95^{th} percentile on the CDC BMI-for-age growth charts. With increasing childhood weight there is an increased risk in health related issues.

The use of infant formula has been thought to increase the risk of childhood obesity, but research is inconclusive to whether infant feeding practices are related to childhood body composition. Studies have found that breast feeding may have protective effect again childhood overweight and underweight, but there are other factors such as maternal weight status, ethnicity, and lifestyle habits that may confound these results. Other studies have shown differences in infant weight status for those who are fed formula versus breast milk, but these differences are not seen after one year of age.

The purpose of this study is to determine if there is a relationship between infant feeding practices and childhood body composition and anthropometrics. Infant feeding practices for this study includes a) exclusively breast fed, b) bottle fed with expressed breast milk, c) exclusively formula fed and d) mixed feeding with formula and human milk. Most research does not include human milk fed by bottle or take into account mixed feeding practices. Some of the published reports use childhood anthropometrics as a surrogate marker of adiposity instead of measuring actual fat mass and fat free mass. This study includes childhood anthropometrics (BMI-for-age percentiles) and body composition (fat mass, fat free mass and percent body fat).

We used multiple linear regression data analysis to assess the relationship between infant feeding practices and each of the body composition and anthropometric measurements (fat mass, fat free mass, percent body fat, and BMI-for-age percentile at three, four and five years old). We used a stepwise process to remove maternal confounding variables (maternal PPVT, race, smoking status, long chain polyunsaturated fatty acid supplementation during pregnancy and pre-pregnancy BMI) that had a change in significance of greater than 0.1 on the variability of the childhood body composition and anthropometric measurement. In the final model, we found no significant relationships between infant feeding practices at four months old and childhood body composition at five years of age and anthropometrics at three, four and five years old.

This study has similarities with the recent research showing no difference between infant feeding practices on childhood body composition and anthropometrics. Although, there have been a few studies showing positive relationships between infant feeding practices and childhood weight status. These studies also determined that maternal characteristics confound or influence these findings, indicating there are other factors involved with childhood overweight and obesity. Childhood overweight and obesity may be influenced more by parental genetic factors or by childhood activity and dietary habits than infant feeding practices.

Acknowledgements

This project was made possible by the KUDOS research staff at The University of Kansas Medical Center. I would like to express my appreciation to my thesis advisor, Dr. Susan Carlson, for her knowledge and guidance. Also, many thanks to my thesis committee Dr. Holly Hull and Beth Kerling, MS, LD, RD. I would like to extend a special thank you to Jocelynn Thodosdoff, MS, RD, LD and Beth Kerling, MS, RD, LD who helped with many aspects of this thesis. I would also like to extend my gratitude for their time and help with the statistical analysis for this project to Brandon Hidaka, MD PhD student, Sharmila Vetri Villalan PhD student, and Jill Shaddy, MA. Thank you all for your time and assistance.

Table of Contents

List of Figures and Tables

Chapter 1

Introduction

The use of infant formula is thought to increase the risk of childhood overweight and obesity (1), but research has been inconclusive to whether infant feeding practices are related to childhood body composition (2, 3). Studies discussed in the literature review assess duration of infant breast feeding (2-8), initiation of complementary foods (3, 4, 7) and delivery mode of infant feeding (9) in relation to body composition and anthropometrics in children and infants.

Specific measurements of infant and childhood body composition and anthropometrics vary among published reports. Four studies measured anthropometrics; height, weight, body mass index (BMI), and z-scores for weight-for-height (2, 4-7) as surrogate markers of adiposity while two studies measured fat mass, fat free mass and percent body fat, using magnetic resonance imaging (8) and dual-energy X-ray absorptiometry (7).

The age of the children also varied among the studies, some focused on infants and children as young as two years old while others looked at adolescents. The studies found that body composition and anthropometrics were different for infants who were breast fed verses formula fed before the age of one, but those differences were not significant after twelve months of age (3). Other studies found that breast feeding may have an effect on overweight and underweight in childhood (5, 8), but ethnicity (5), maternal weight (2) and behavioral habits (6) confound these results. The lack of consensus of the combined studies may be due to the variety of study methods and covariates used.

Infant feeding practices vary with some parents utilizing breast feeding, bottle feeding of expressed breast milk, exclusive formula feeding and a combination of human milk and formula for their infant within the first year. Many of the studies compare formula feeding versus breast feeding without considering that many women now provide breast milk from a bottle and the use of human milk along with formula (2-8). The frequency of these feeding modes throughout the child's first year should be taken into account in comparing infant feeding to childhood body composition. The mode of feeding rather than the composition of the feeding could be the factor that influences childhood weight status via a mechanism such as learned self-regulation. Another limitation of the literature is that surrogates for body composition (e.g. BMI-for-age percentile) have been assessed rather than calculated fat mass and fat free mass.

For this study, we utilized data from the longitudinal Kansas University DHA Outcomes Study (KUDOS) cohort from the University of Kansas Medical Center (10). The cohort is being followed through six years of age since pregnancy. Feeding and anthropometric data (height, weight and head circumference) were collected five times during infancy. Anthropometric measurements were taken every six months from the age of one to six years old. Body composition through air displacement plethysmography to determine fat mass, fat free mass and percent body fat was evaluated at the age of five. Data were also collected on maternal characteristics including weight status, smoking history, race, ethnicity and long chain polyunsaturated fatty acid supplementation in the original KUDOS trial.

Purpose of the Study

The purpose of this study is to determine the relationship of infant feeding practices including; a) exclusive breast feeding, b) expressed breast milk fed by bottle, c) exclusive formula fed by bottle and d) combination of human milk and formula on childhood body composition using air displacement plethysmography to assess fat mass, fat free mass and percent body fat at the age of five. A second aim of this study is to determine if infant feeding practices are related to BMI-for-age percentiles at three, four and five years of age.

Research questions

1. Does infant feeding mode relate fat mass, fat free mass or percent body fat at five years of age?
2. Does infant feeding mode relate to BMI-for-age percentile at three, four or five years of age?

Chapter 2

Literature Review

Introduction

It's well known in the pediatric community that the incidence of childhood overweight and obesity have increased in the United States. Overweight is defined as at or above the 85th percentile and less than the 95th percentile on the CDC BMI-for-age growth charts (11). Obesity is defined as at or above the 95th percentile on the CDC BMI-for-age growth charts (1). According to the 2009-2010 National Health and Nutrition Examination Survey (NHANES), 31.8% of children and adolescents ages two to nineteen in the US are either overweight or obese (11). In 2009 to 2010, 12.1% of children age two to five and 18% of children six to eleven were classified as obese (11).

With increasing childhood weight there is an increase in health related issues. The health problems related to childhood obesity include increased risk of cardiovascular disease, prediabetes, bone and joint issues, sleep apnea and adverse social concerns at a young age (12). Obese children are more likely to be obese when they become adults (12). Leading to the long term health risks of childhood obesity: heart disease, type 2 diabetes, stroke, osteoarthritis and several types of cancer (12). Prevention of childhood weight gain has been a focus of many in the scientific field. Feeding during infancy has been identified as a critical time point for childhood overweight and obesity development because the child learns to respond to hunger, satiety cues (1, 13) and self-regulation (1).

The American Academy of Pediatrics and the Pediatric Nutrition Care Manual recommend feeding breast milk exclusively for the first six months of infancy. Complementary foods should be started at six months of age with breastfeeding continuing until at least one year of age (1, 13). These recommendations are not always observed. The rate of mothers and infants who exclusively breast feed for six months is 13% within the total United States population (1). For those who breast feed for any duration of time until six months of age is 43% (1). The rate of breast feeding has been increasing in the United States, with the largest increase between the years 2008 and 2009 (14). Breast feeding rates differ for ethnic and socioeconomic populations. The rate of breast feeding initiation in the Hispanic population is 80.6% and in the non-Hispanic black population is 58.1% (1). The breast feeding initiation rate is 67.5% in lower income women and 84.6% in higher income women (1).

Breast feeding is associated with many infant health benefits including decreased risk of respiratory tract infections, urinary tract infections, diarrhea, bacterial meningitis, sepsis, sudden infant death syndrome, asthma and diabetes (13). Research is conflicting on whether breast feeding is protective against childhood obesity development. The purpose of this review is to examine infant feeding practices related to childhood overweight and obesity.

The search and review process consisted of using PubMed, CINAHL and Google Scholar for past research articles. The key phrases breastfeeding, infant formula, infant feeding, pediatric body composition and body composition were search terms. The inclusion criterions were healthy term infants born to healthy mothers and weight status outcomes. Studies of children over the age of seven and studies conducted outside of the United States were excluded.

The studies found assessed childhood anthropometrics and body composition with regard to infant feeding practices; including the duration of breast feeding, initiation of complementary foods and delivery mode of breast milk and formula.

Infant feeding practices related to infant anthropometrics and body composition

Seven studies met the criteria for comparing infant feeding practices to infant and childhood anthropometrics and body composition (2-8). One study looked at the relationship between duration of infant breast feeding and infant anthropometrics (3). The data reported in the study were collected from two-year-old participants in the Children's Nutrition Research Center in Houston, Texas (3). Butte et al (3) used weight, length, weight-for age, length-for-age and weight-for-age z-scores. The average duration of infant breast feeding was eleven and a half months (3). Duration of infant breast feeding did not have an effect on the child's weight status after one year of age. Weight differences in early infancy were found. Infants who were breast fed gained weight at a slower velocity than those who were formula fed between the ages of three to six months (3). There were no anthropometric markers (weight-for-age, length-for-age and length-for-age z-scores) at two years of age that showed differences for those at any breast feeding duration (3).

Butte et al (3) also assessed the relationship between duration of infant breast feeding and infant body composition using total body electric conductivity, H_20 dose for total body water, DXA, total body potassium and multicomponent body composition model. Differences in body composition were not seen after the age of one for those who breast fed for any duration. Fat free mass was lower while fat mass and percent body fat were higher in breast fed infants than formula fed infants at three and six months of age, but not at twelve, eighteen, and twenty-four months (3).

The relationship between the initiation of solid food and infant body composition was analyzed by Butte et al (3). Food intake was assessed during a three day period at three and six month intervals by weighed averages (3). There were differences in body composition at three to nine months of age, specifically fat mass and percent body fat were higher and fat free mass was lower in the group who were breast fed after the introduction of solids, however, these differences were not seen after the age of one (3).

Infant feeding practices related to childhood anthropometrics and body composition

Research studies relating duration of infant breast feeding to childhood anthropometrics will be considered next (2, 4-7). These studies reported data collected from NHANES III (4), Ohio WIC (2), CDC Pediatric Nutrition Surveillance System (5), and in Massachusetts Obstetrician/Gynecologist offices (6). Burdette et al (7) did not disclose where the data were collected. The studies assessed weight, height (4, 6, 7), BMI (2, 4, 5), weight-for-height, weight-for-height z-scores (2) and BMI z-scores (6) for children aged three to five years old as surrogate markers of adiposity (2, 4-7). The duration of infant breast feeding was determined by the age when breast feeding stopped (2, 4-7). Gillman et al (6) assessed multiple behavioral and lifestyle risk factors during infancy that may be associated with childhood obesity, including the duration of breast feeding. Exclusive breast feeding varied within the studies, for example Bogen (2) studied 11,913 (16%) participants who were exclusively breast fed for eight weeks (2) while a smaller study found that 30% of participants were exclusively breast fed until four months (7), another that 9.2% were exclusively breast fed until six months (4). Another large study (n=177,304) found that 6.1% of participants were exclusively breast fed for more than six months (5). Lastly, one study of 1,110 women found that 73% of participants were exclusively breast fed for twelve months (6).

There was a decreased risk of childhood overweight for infants who were breast fed, for any duration of time, compared to those who were never breast fed (4). Duration of breast feeding also varied with maternal weight status. Mothers who were underweight tended to breast feed for a shorter duration of time than normal weight mothers (4). Overweight and obese mothers were more likely (50%) to never breast feed (4). Duration of breast feeding had an effect on childhood weight. Grummer-Strawn et al (5) reported that infants who were never breast fed had an increased risk of being underweight or overweight at four years old. Bogen et al (2) reported rates of breast feeding increased by 25% within the years of study, but there was also effects of ethnicity and lifestyle behaviors on childhood overweight during those years.

A few studies suggest maternal, ethnic or behavioral factors may confound the results. Bogen et al (2) states maternal overweight is the indicator most associated with childhood obesity. Grummer-Strawn et al (5) found longer duration of breast feeding reduced the rate of being overweight for non-Hispanic white children but not for other ethnicities. Gillman et al (6) evaluated risk of childhood overweight and found it was associated with an increase in multiple risk factors. Short breast feeding duration resulted in an odds ratio of 1.8 compared to longer breast feeding, but this odds ratio increased further with exposure to more behavioral or lifestyle risk factors (6).

Crume et al (8) and Burdette et al (7) compared childhood body composition with infant breast feeding duration. Crume et al (8) reported data collected from the Exploring Perinatal Outcomes Among Children Study in Denver for six to thirteen year old children. The studies assessed body composition using magnetic resonance imaging of the abdominal region for visceral adipose tissue (VAT), and subcutaneous adipose tissue (SAT) with 3-T system, IMCL assessed by magnetic resonance spectroscopy (8), DXA including lean body mass, fat mass and percent body fat (7). Questionnaires were used to determine exclusive breast feeding and exclusive formula feeding for specific month durations (7, 8). Crume et al (8) also assessed the combination of formula use with breast feeding where the participants were grouped according to the frequency they received formula. There was not a significant difference in body composition in five year olds (7) and in adolescents (8) with regard to whether they were breast fed or formula fed at any duration of time during infancy. Although, being overweight or underweight in adolescents was associated with never being breast fed (8).

Hediger et al (4) and Burdette et al (7) took into consideration the initiation of solids during infancy relating to childhood anthropometrics and body composition. Assessing the age in months when solids were first introduced, Hediger et al (4) found for each month solids were delayed there was a 0.1% reduction in the risk of childhood overweight using weight, height and BMI. Burdette et al (7) focus of research was the relationship of complementary foods to adiposity. The infants were separated into categories of initiation of complementary foods according to the American Academy of Pediatrics' recommendations (7). The recommendations were followed by half the mothers in the study (7). Burdette et al (7) did not find a relationship between childhood body composition and the introduction of solids during infancy.

Potential mechanism for a protective effect of childhood obesity

Another potential protection against childhood obesity may be related to the delivery mode of breast milk and formula. Delivery mode was assessed in the infant's first six months of life to determine if infants in the second six months of life emptied their cup or bottle more frequently as an indicator for self-regulation (9). Poor self-regulation is a possible mechanism for childhood obesity which was not examined in this study (9). To determine delivery mode in the first half year of life, the infants were divided into four feeding categories; breastfed milk, expressed breast milk by bottle, formula fed by bottle, and other milks fed by bottle (9). The frequency of which they were fed by a particular mode was also assessed because it's common that infant feeding practices change. The infants were again separated into groups based on how often they fed by these different modes (9).

Infants fed by bottle in early infancy are more likely to finish their cup in late infancy compared to breast fed infants (9). Also, infants who fed more frequently from a bottle was twice as likely to finish their cup in late infancy as infants who fed from a bottle infrequently, regardless of the feeding (expressed breast milk or formula) (9).

Critical analysis

The results regarding infant feeding practices and its relationship to infant and childhood obesity are inconclusive. Infant breast feeding duration did not have a consistent effect on childhood weight and body composition, although, any breast feeding seemed to have a protective effect against childhood overweight and underweight compared to never being breast fed. There may be a risk of childhood overweight with combined risk factors including; ethnicity, maternal weight status, and other lifestyle behaviors that include formula feeding or a shortened duration of breast feeding.

Initiation of solid foods during infancy had a slight effect on childhood weight status, but this was only shown in one out of the two studies assessing complimentary foods. Delivery mode may have an effect on childhood overweight, e.g., the tendency to finish a cup or bottle in late infancy suggests poorer self-regulation, a possible mechanism for childhood overweight. Yet, this was not the conclusion in a research study.

The studies did not have consistent methods of assessing the relationship between infant feeding practices and childhood weight status and body composition. This may be the reason for inconsistencies among the results of the studies. There are many factors to consider during infant feeding. Breast milk may have a protective effect on childhood overweight and obesity considering most of the studies did find lower childhood weights with those who breast fed. The feeding mode of breast milk may have an effect on childhood weight status; i.e., whether the breast milk is fed to infants by breast or by bottle. Li et al (9) found that bottle feeding had an effect on self-regulation in late infancy, which may have an effect on childhood body composition. The relationship of infant feeding delivery mode was only assessed to find an effect on self-regulation in late infancy. We are not aware of any studies that have looked at mode of feeding in relation to childhood body composition and anthropometrics.

Conclusion

In conclusion, infant feeding practices vary and include breast feeding, bottle feeding of human milk and bottle feeding with infant formula. Both composition and mode of feeding may influence body composition in childhood. In studies to date, the mode of human milk feeding has not been considered in comparing infant feeding source and childhood body composition. It is the goal of my study to determine if mode of feeding may be a confounder in studies that have evaluated childhood weight status in relation to human milk or infant formula feeding in infancy.

Chapter 3

Materials and Methods

Background

The sample of children for this study was a subset of the Kansas University DHA Outcomes Study (KUDOS) cohort from The University of Kansas Medical Center (KUMC). The KUDOS study is a phase III, double-blind, randomized controlled trial to evaluate the effect of docosahexaenoic acid (DHA) supplementation during pregnancy on gestation duration and infant visual acuity and cognition (10). Women (n=350) were randomized to receive either 600mg DHA or a placebo during the last two trimesters of pregnancy (10). The children are now being followed until the age of six to assess cognitive development. The children are currently between the ages of three and seven.

Design

Maternal characteristics, infant feeding, anthropometrics and body composition were collected prospectively throughout the KUDOS trial. Infant feeding practices consist of mode (breast or bottle) and composition (human milk or formula) collected at six weeks, four months, six months, nine months, twelve months, and eighteen months using 24 hour dietary recalls.. Infants were grouped into five feeding classifications; a) exclusively breast fed, b) expressed breast milk fed by bottle, c) exclusively formula fed, d) mixed feeding of both human milk and formula and e) a small unknown category because of missing or unspecified data which were not used in the data analysis. Infant anthropometrics (length and weight) were collected at six weeks, four months, six months, nine months, twelve months and eighteen months visits. Graphs were developed for this study to look at infant growth among each infant feeding practice classification throughout infancy until eighteen months old, without including maternal covariates.

Childhood anthropometrics (height, weight) were collected every six months from the age of two to six years old. Body composition (fat mass, fat free mass and percent body fat) was assessed using air displacement plethysmography with a Bod Pod at five years of age. Statistical analysis were conducted using body composition data at five years of age and anthropometric data at three years, four years and five years of age to determine a relationship between infant feeding practices and childhood body composition and anthropometrics.

Sample

Seventy-four children were included in the primary aim analysis. Both feeding history and body composition (fat mass, fat free mass, and percent body fat) are known for this sample. This sample of five year olds is less that the sample of five year olds with anthropometric data because of refusal to conduct the Bod Pod assessment or missing data. The sample of children for the secondary research question varies in number because some children from the original cohort have yet to reach the age of four or five years old. There are 174 three year old children, 153 four year old children and 86 five year old children. The children's infant feeding practices were collected at four months of age. The anthropometric data (height, weight) were collected at the age of three, four and five. Height and weight measurements were converted to BMI (kg/m^2) and entered into Epi Info version 3.5.4 to be calculated into percentiles according to the Center for Disease Control and Prevention (CDC) 2000 growth references.

Research Setting

The women for the KUDOS trial were recruited from the Kansas City metropolitan area. Participants (mothers and offspring) had regular study visits at the Maternal and Child Nutrition and Development Laboratory located in Smith West at KUMC throughout infancy and childhood. The study visits for the offspring were conducted at six weeks, four months, six months, nine months, twelve months, and every six months starting at one year of age until six years of age. At these visits, anthropometrics (height, weight and head circumference), 24 hour dietary recalls, vision and cognition tests were conducted. Body composition (fat mass, fat free mass and percent body fat) was analyzed at five years old using air displacement plethysmography.

Ethics

The primary KUDOS study is under the HSC protocol number 10186. The University of Kansas Medical Center Human Subjects Committee reviewed and approved the KUDOS study at an earlier date (10). Parent participant consent was obtained for body composition measurements at the 4.5 year visit. The consent form is located in Appendix B.

Data Collection

<u>Maternal Characteristics</u>

Data collected for the maternal characteristics are confounding factors that influence infant and childhood anthropometrics and body composition. Maternal PPVT was collected using the Peabody Picture Vocabulary Test (PPVT). Maternal income was collected by zip code as indicated at the mother's first KUDOS clinic visit. Maternal age at enrollment was collected.

Maternal age, income and PPVT are highly correlated with each other. By conducting a linear regression among these correlated confounding variables, we found that maternal PPVT has the highest proportion of variability on childhood body composition.

Along with maternal PPVT, other confounding variables that were collected and used in the statistical analysis were maternal pre-pregnancy BMI that was calculated from maternal height and weight measurements from her first KUDOS clinic visit. Maternal smoking data was collected and dichotomized to nonsmoker or smoker (smoked at any time point before or during pregnancy). Maternal race was collected and dichotomized into white or non-white. Long chain polyunsaturated fatty acid (LCPUFA) supplementation during pregnancy has been found to influence childhood body composition and was used as a covariant for this study. The mother's LCPUFA designation from the original KUDOS pregnancy trial was collected and dichotomized to whether she took placebo or the LCPUFA supplement.

Infant Feeding Practices

Infant feeding practices of mode (breast or bottle) and composition (human milk or formula) were collected for the infant at six weeks, four months, six months, nine months, twelve months and eighteen months for the KUDOS trial. Discussion among the thesis committee determined infant feeding data for this study to be collected at four months of age because feeding practices are stabilized by four months and before the infant starts complimentary foods. Mode and composition of the infant feeding practices were evaluated. Participants were divided into feeding classifications; a) exclusively breast fed, b) fed with expressed breast milk, c) exclusively formula fed, d) mixed feeding with human milk and formula.

The 24 hour recall form at four months of age was used to determine feeding practices (see Appendix A). Exclusively breast fed infants were only fed human milk from the breast. The infants that were separated into the expressed breast milk category were fed human milk by the breast and fed expressed human milk with a bottle at least once. The exclusively formula fed infants were only fed infant formula from a bottle. The infants that were separated into the mixed feeding category were fed human milk by breast or bottle and fed infant formula. There were six participants that were separated into an unknown category because of missing 24 hour recall forms or the information was unclear whether the infant fed human milk by breast or a bottle. These six participants were dropped and the data was not used for the analysis for this study.

Body Composition

Body composition was evaluated at the child's five year visit using air displacement plethysmography with a Bod Pod. The consent form used in the KUDOS follow up trial is listed in Appendix B. The participants wore identical approved swim wear (separate for males and females) and swim caps for the evaluation. The Bod Pod evaluates fat mass and fat free mass by measuring the participant's weight using an automated scale and the participant's volume inside the Bod Pod with air displacement. Density is calculated (density = weight/volume) with the participant's weight and volume. Fat mass and fat free mass are determined using the Lohman body density model designed for children younger than seventeen.

Anthropometrics

Infant length and weight measurements were taken at six weeks, four months, six months, nine months, twelve months and eighteen months. The infant anthropometric data collection form is listed in Appendix C. The length measurements were taken using length board to measure recumbent length to the nearest tenth of a centimeter. Infant weight was obtained using a calibrated pediatric scale and recorded to the nearest gram. These measurements were used to calculate BMI (kg/m^2) and plotted on a graph as a representation of anthropometric measurements over the first year and a half.

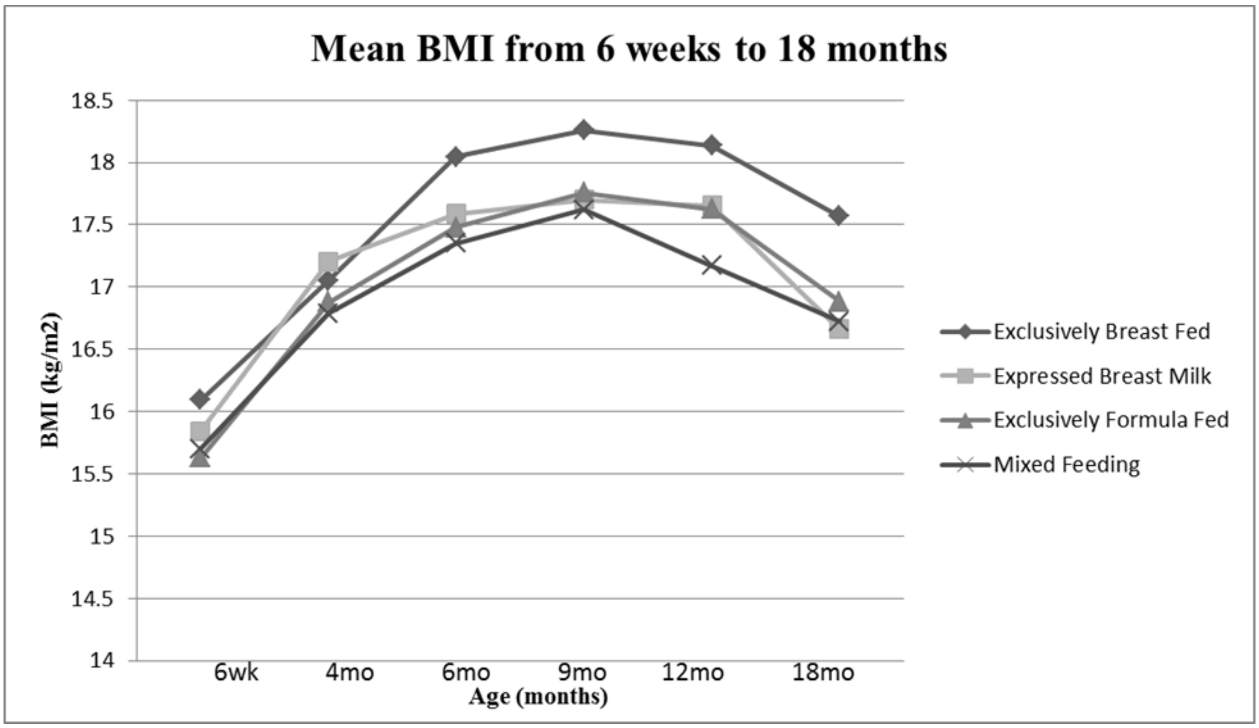

Figure 1: Mean BMI from six weeks to eighteen months for the infant feeding practices

The weight and length measurements were also entered into Epi Info version 3.5.4 and calculated into weight-for-length percentiles according to the CDC 2000 growth references, as traditionally used to assess infant growth. The mean weight-for-length percentiles were plotted on a graph to represent anthropometric measurements over the first year and a half.

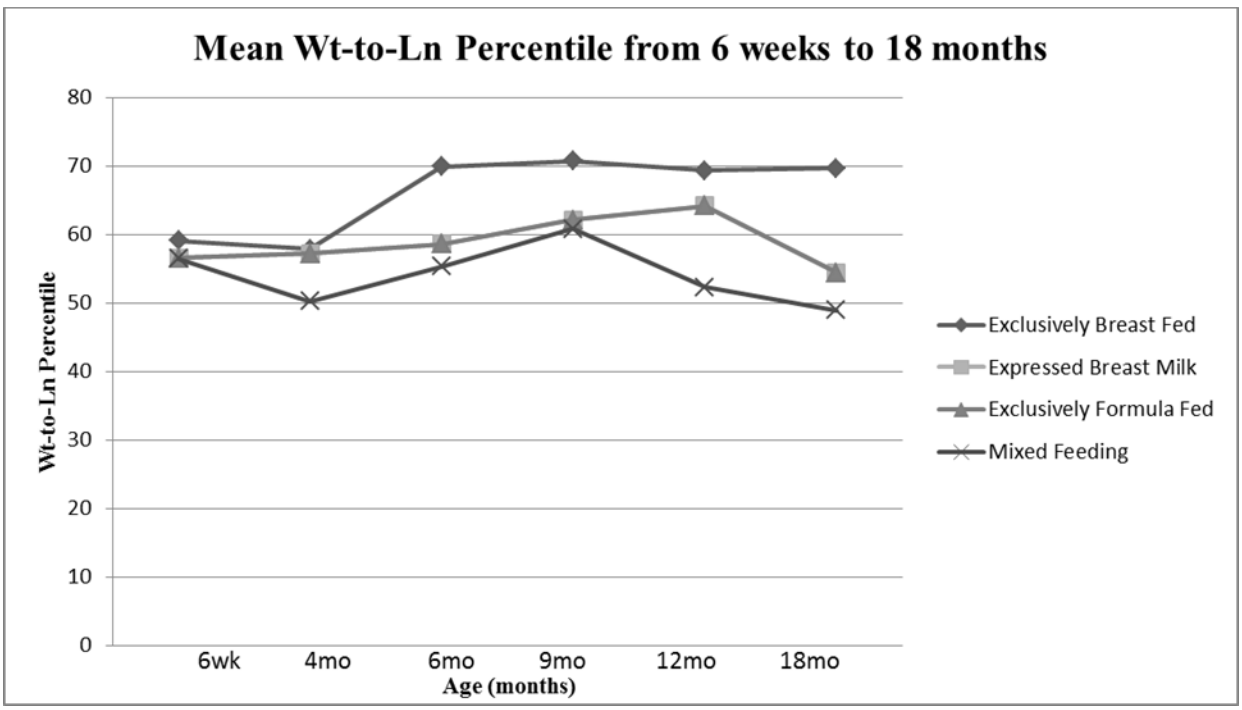

Figure 2: Mean weight-for-length percentile from six weeks to eighteen months for the infant feeding practices

Height and weight measurements were taken for the participants every six months starting at the age of two years old. The childhood anthropometric data collection form is listed in Appendix D. Height was taken standing without shoes using a stadiometer and measured to the nearest tenth of a centimeter. Weight was taken on an automated scale without shoes or heavy outer layer (coat) and measured to the nearest tenth of a kilogram. Height and weight were used to calculate BMI (kg/m^2) and entered into Epi Info version 3.5.4 to be calculated into BMI-for-age percentiles according to the CDC 2000 growth references. Mean BMI-for-age percentiles from the child's three year, four year and five year visit were used for this study.

Data Analysis

Multiple linear regressions were used to analyze the infant feeding practices, body composition and anthropometric data. Data was organized in a Microsoft Excel spreadsheet then transferred to IBM SPSS Statistics 20 to conduct the infant feeding practice and childhood body composition and anthropometric analysis.

The childhood body composition (fat mass, fat free mass and percent body fat) and anthropometric measurements (BMI-for-age percentile at three, four and five years old) were set as the dependent variable in each analysis. Maternal confounding variables (PPVT, race, smoking status, LCPUFA supplementation during pregnancy and pre-pregnancy BMI) and infant feeding practices were added into the model in a stepwise fashion. The R-Square was used to determine the proportion of variance in the body composition or anthropometric measurement that can be explained by the confounding variable and infant feeding practice. The Significance of F Change was used to determine the significance of change that the confounding variable had on the dependent variable and was removed from the model if greater than 0.1.

Each dependent variable (body composition and anthropometric measurement) has two models reported. A model that contains all confounding and feeding practice variables and the final model with the best fit according to the significance of change on the dependent variable.

Chapter 4

Results

The purpose of this thesis was to determine if there is a relationship between infant feeding practices on childhood body composition and anthropometrics. The sample was from the Kansas University DHA Outcome Study (KUDOS) cohort at The University of Kansas Medical Center (KUMC). Infant feeding practices were divided into feeding classifications; a) exclusively breast fed, b) fed expressed breast milk by bottle, c) exclusively formula fed and d) mixed feeding with formula and human milk which were analyzed with childhood body composition and anthropometrics, using pertinent maternal characteristics as covariates.

Subject Characteristics

Maternal characteristics were collected and used as confounding variables for analyzing childhood body composition and anthropometrics. This data is shown below in Table 1. The table shows subgroup characteristics for the primary and secondary research questions. Means and standard deviations are stated for maternal PPVT and maternal pre-pregnancy BMI. Maternal smoking status (yes or no), race (white or non-white) and LCPUFA supplementation during pregnancy from the KUDOS trial (placebo or LCPUFA) were dichotomized.

Table 1: Maternal characteristics

Maternal Characteristics	Subset with Body Composition At 5 years of age	Subset Available for BMI Percentile		
	n=74	Age 5 years n=86	Age 4 years n=153	Age 3 years n=174
IQ* determined by PPVT**	98.2 ± 16.5	98.1 ± 15.6	98.8 ± 15.1	98.8 ± 15.2
Pre-pregnancy BMI (kg/m^2)*	23.4 ± 8.29	23.2 ± 9.32	22.4 ± 9.93	22.1 ± 10.21
Smoker at any time [n(%)]	33(45)	37(43)	70(46)	81(47)
White [n(%)]	45(61)	51(59)	95(62)	109(63)
LCPUFA*** supplementation n(%)	33(45)	39(45)	80(52)	93(53)

***** Mean ± standard deviation
**Peabody Picture Vocabulary Test
***Long chain polyunsaturated fatty acids

Infant feeding practices were categorized for the participants in the KUDOS trial. Infant feeding at the age of four months old was collected and determined to be either; a) exclusively breast fed, b) fed with expressed breast milk, c) exclusively formula fed, and d) mixed feeding with both formula and human milk. The data for infant feeding data is shown in Table 2. The table shows subgroup characteristics for the primary and secondary research questions.

Table 2: Infant feeding practices

Feeding Practice Classifications	**Subset with Body Composition at 5 years**	**Subset Available for BMI Percentile**		
	n=74	Age 5 years n=86	Age 4 years n=153	Age 3 years n=174
Exclusively Breast Fed n(%)	8(11)	11(13)	25(16)	28(16)
Expressed Breast Milk n(%)	10(14)	10(12)	22(14)	25(14)
Exclusively Formula Fed n(%)	44(59)	52(60)	80(52)	93(53)
Mixed Feeding n(%)	12(16)	13(15)	26(17)	28(16)

Childhood body composition and anthropometrics

Infant feeding practices were analyzed with five year old body composition measurements to answer the primary research question. Only 74 of the 183 participants from the KUDOS trial have reached five years old and completed the Bod Pod assessment. The data for the participants that have had their body composition (fat mass, fat free mass and percent body fat) assessed by the Bod Pod are listed in Table 3. The mean fat mass was 4.85 kg, the mean fat free mass was 14.96 kg and the percent body fat was 24.37%.

Table 3 also consists of anthropometric data (BMI and BMI percentile) for the three, four and five year olds in the subset analyzed for the secondary research question. The mean BMI was 16.4 and the mean BMI-for age percentile was 66.5 for the 86 five year olds who have had their anthropometrics measured. Of the 153 four year old participants the mean BMI was 16.4 and the mean BMI-for-age percentile was 65.1. The mean BMI-for-age percentile for the three year olds was 62.6 and the mean BMI was 16.4.

Table 3: Childhood Characteristics

Childhood Characteristics	**Body Composition at 5 years**	**BMI Percentile**		
	n=74	Subset of 5 year old cohort n=86	Subset of 4 year old cohort n=153	Subset of 3 year old cohort n=174
Fat free mass (kg)*	14.96 ± 2.51			
Fat mass (kg)*	4.85 ± 1.47			
Percent body fat (%)*	24.37 ± 5.97			
BMI (kg/m^2)*		16.37 ± 1.71	16.36 ± 1.49	16.56 ± 1.31
BMI-for-age percentile*		66.45 ± 26.46	65.08 ± 27.50	62.55 ± 26.77

*****reported as mean ± standard deviation

The relationship between infant feeding practices and five year old body composition

The relationship of infant feeding practices on fat mass

The model summary for the relationship of infant feeding practices on fat mass at five years old is shown in Table 4. The analysis shows the change in variability of fat mass does not increase significantly with the addition of the confounding maternal variables. We removed those variables that have a change of >0.1 significance to find the best fit model. Maternal race, smoking, LCPUFA supplementation during pregnancy and pre-pregnancy BMI were removed from the model.

Table 5 shows the final model summary for the relationship of infant feeding practice on fat mass with maternal PPVT as the confounding variable. Statistical significance was determined by a p-value of <0.05. There is no significant relationship between infant feeding practices at four months of age on fat mass at five years of age.

Table 4: Model summary for the relationship of infant feeding practices on fat mass (kg) at five years old (n=74)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.202[a]	.041	.028	1.493	.041	3.066	1	72	.084
2	.215[b]	.046	.019	1.499	.005	.408	1	71	.525
3	.225[c]	.051	.010	1.507	.004	.327	1	70	.569
4	.232[d]	.054	-.001	1.515	.003	.217	1	69	.643
5	.245[e]	.060	-.009	1.521	.006	.458	1	68	.501
6	.313[f]	.098	-.013	1.524	.038	.904	3	65	.444

a Predictors: (Constant), maternal PPVT
b Predictors: (Constant), maternal PPVT, race
c Predictors: (Constant), maternal PPVT, race, smoking
d Predictors: (Constant), maternal PPVT, race, smoking, LCPUFA
e Predictors: (Constant), maternal PPVT, race, smoking, LCPUFA, maternal BMI
f Predictors: (Constant), maternal PPVT, race, smoking, LCPUFA, maternal BMI, mixed feeding, expressed breast fed, formula fed

Table 5: Model summary for the best fit relationship of infant feeding practices on fat mass (kg) at five years old (n=74)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.202[a]	.041	.028	1.493	.041	3.066	1	72	.084
2	.270[b]	.073	.019	1.499	.032	.800	3	69	.498

a. Predictors: (Constant), maternal PPVT
b. Predictors: (Constant), maternal PPVT, mixed feeding, expressed breast fed, formula fed

The relationship of infant feeding practices on fat free mass

The model summary for the relationship of infant feeding practices on fat free mass at five years old is shown in Table 6. The analysis shows the change in variability of fat free mass does not increase significantly with the addition of the confounding maternal variables. We removed those variables that have a change of >0.1 significance. Maternal PPVT, race, smoking and LCPUFA supplementation during pregnancy were removed from the model.

Table 7 shows the final model summary for the relationship of infant feeding practice on fat free mass with maternal pre-pregnancy BMI as the confounding variable. There is no significant relationship between infant feeding practices at four months of age on fat mass at five years old. Maternal pre-pregnancy BMI did explain 6.5% of the proportion of variability of childhood fat free mass indicated by R^2 with a change of significance of p=0.028.

Table 6: Model summary for the relationship of infant feeding practices on fat free mass (kg) at five years old (n=74)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.069[a]	.005	-.009	2.554	.005	.349	1	72	.557
2	.092[b]	.009	-.019	2.567	.004	.266	1	71	.608
3	.174[c]	.030	-.011	2.557	.022	1.569	1	70	.215
4	.238[d]	.057	.002	2.540	.026	1.931	1	69	.169
5	.346[e]	.120	.055	2.471	.063	4.861	1	68	.031
6	.378[f]	.143	.037	2.494	.023	.586	3	65	.626

a. Predictors: (Constant), maternal PPVT
b. Predictors: (Constant), maternal PPVT, race
c. Predictors: (Constant), maternal PPVT, race, smoking
d. Predictors: (Constant), maternal PPVT, race, smoking, LCPUFA
e. Predictors: (Constant), maternal PPVT, race, smoking, LCPUFA, maternal BMI
f. Predictors: (Constant), maternal PPVT, race, smoking, LCPUFA, maternal BMI, mixed feeding, expressed breast fed, formula fed

Table 7: Model summary for the best fit relationship of infant feeding practice on fat free mass (kg) at five years old (n=74)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.255[a]	.065	.052	2.475	.065	5.019	1	72	.028
2	.298[b]	.089	.036	2.496	.024	.599	3	69	.618

a. Predictors: (Constant), maternal BMI
b. Predictors: (Constant), maternal BMI, expressed breast fed, mixed feeding, formula fed

The relationship of infant feeding practices on percent body fat

The model summary for the relationship of infant feeding practices on percent body fat at five years old is shown in Table 8. The analysis shows the change in variability of percent body fat does not increase significantly with the addition of the confounding maternal variables. We removed those variables that have a change of >0.1 significance. Maternal PPVT, race, smoking and LCPUFA supplementation during pregnancy were removed from the model.

Table 9 shows the model summary for the relationship of infant feeding practice on percent body fat with maternal pre-pregnancy BMI as the confounding variable. Statistical significance was determined by having a p-value of <0.05. There is no significant relationship between infant feeding practices at four months of age on percent body fat at five years old.

Table 8: Model summary for the relationship of infant feeding practices on percent body fat at five years old (n=74)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.163[a]	.026	.013	5.951	.026	1.956	1	72	.166
2	.180[b]	.032	.005	5.975	.006	.439	1	71	.510
3	.180[c]	.032	-.009	6.017	.000	.003	1	70	.958
4	.213[d]	.045	-.010	6.020	.013	.930	1	69	.338
5	.294[e]	.086	.019	5.933	.041	3.037	1	68	.086
6	.334[f]	.111	.002	5.984	.025	.616	3	65	.607

a. Predictors: (Constant), maternal PPVT
b. Predictors: (Constant), maternal PPVT, race
c. Predictors: (Constant), maternal PPVT, race, smoking
d. Predictors: (Constant), maternal PPVT, race, smoking, LCPUFA
e. Predictors: (Constant), maternal PPVT, race, smoking, LCPUFA, maternal BMI
f. Predictors: (Constant), maternal PPVT, race, smoking, LCPUFA, maternal BMI, mixed feeding, expressed breast fed, formula fed

Table 9: Model summary for the best fit relationship of infant feeding practices on percent body fat at five years old (n=74)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.185[a]	.034	.021	5.928	.034	2.548	1	72	.115
2	.245[b]	.060	.006	5.973	.026	.636	3	69	.594

a. Predictors: (Constant), maternal BMI

b. Predictors: (Constant), maternal BMI, expressed breast fed, mixed feeding, formula fed

The effect of infant feeding practices on childhood anthropometrics

The relationship of infant feeding practices on three year old BMI-for-age percentile

The model summary for the relationship of infant feeding practices on BMI-for-age percentile at three years old is shown in Table 10. The analysis shows the change in variability of BMI-for-age percentile does not increase significantly with the addition of the confounding maternal variables. We removed those variables that have a change of >0.1 significance. All maternal characteristics were removed from the model.

Table 11 shows the model summary for the relationship of infant feeding practice on three year old BMI-for-age percentile with no maternal characteristic as confounding variables. There is also no significant relationship between infant feeding practices at four months of age on BMI-for-age percentile at three years old.

Table 10: Model summary for the relationship of infant feeding practices on BMI-for-age percentile at three years old (n=173)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.005[a]	.000	-.006	26.869	.000	.004	1	171	.947
2	.030[b]	.001	-.011	26.936	.001	.153	1	170	.697
3	.093[c]	.009	-.009	26.910	.008	1.320	1	169	.252
4	.140[d]	.020	-.004	26.840	.011	1.893	1	168	.171
5	.149[e]	.022	-.007	26.887	.002	.413	1	167	.521
6	.244[f]	.060	.014	26.604	.038	2.189	3	164	.091

a. Predictors: (Constant), maternal PPVT
b. Predictors: (Constant), maternal PPVT, race
c. Predictors: (Constant), maternal PPVT, race, smoking
d. Predictors: (Constant), maternal PPVT, race, smoking, LCPUFA
e. Predictors: (Constant), maternal PPVT, race, smoking, LCPUFA, maternal BMI
f. Predictors: (Constant), maternal PPVT, race, smoking, LCPUFA, maternal BMI, mix feeding, expressed breast fed, formula fed

Table 11: Model summary for the best fit relationship of infant feeding practices on BMI-for-age percentile at three years old (n=174)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.177[a]	.031	.014	26.599	.031	1.828	3	170	.144

a. Predictors: (Constant), mixed feeding, expressed breast fed, formula fed

The relationship of infant feeding practices on four year old BMI-for-age percentile

The model summary for the relationship of infant feeding practices on BMI-for-age percentile at four years old is shown in Table 12. The analysis shows the change in variability of BMI-for-age percentile does not increase significantly with the addition of the confounding maternal variables. We removed those variables that have a change of >0.1 significance. Maternal PPVT, race and smoking status were removed from the model.

Table 13 shows the model summary for the relationship of infant feeding practice on BMI-for-age percentile with maternal LCPUFA supplementation during pregnancy and maternal pre-pregnancy BMI as the confounding variables. There is no significant relationship between infant feeding practices at four months of age on BMI-for-age percentile at four years of age. In this model, maternal pre-pregnancy BMI is positively related to BMI-for-age percentile at four years old (p=0.033) and can explain 2.9% of the proportion of variability of four year old BMI-for-age percentile indicated by R^2. Maternal LUPUFA supplementation during pregnancy can explain 3.2% of the proportion of variability of four year old BMI-for-age percentile indicated by R^2 with a change of significance of p=0.027.

Table 12: Model summary for the relationship of infant feeding practices on BMI-for-age percentile at four years old (n=152)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.003[a]	.000	-.007	27.620	.000	.002	1	150	.967
2	.007[b]	.000	-.013	27.712	.000	.006	1	149	.937
3	.058[c]	.003	-.017	27.760	.003	.483	1	148	.488
4	.182[d]	.033	.007	27.435	.030	4.522	1	147	.035
5	.246[e]	.061	.029	27.133	.028	4.297	1	146	.040
6	.270[f]	.073	.021	27.240	.012	.619	3	143	.604

a. Predictors: (Constant), maternal PPVT
b. Predictors: (Constant), maternal PPVT, race
c. Predictors: (Constant), maternal PPVT, race, smoking
d. Predictors: (Constant), maternal PPVT, race, smoking, LCPUFA
e. Predictors: (Constant), maternal PPVT, race, smoking, LCPUFA, maternal BMI
f. Predictors: (Constant), maternal PPVT, race, smoking, LCPUFA, maternal BMI, mixed feeding, expressed breast fed, formula

Table 13: Model summary for the best fit relationship of infant feeding practices on BMI-for-age percentile at four years old (n=153)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.178[a]	.032	.025	27.172	.032	4.965	1	151	.027
2	.247[b]	.061	.048	26.850	.029	4.649	1	150	.033
3	.268[c]	.072	.040	26.966	.011	.571	3	147	.635

a. Predictors: (Constant), LCPUFA

b. Predictors: (Constant), LCPUFA, maternal BMI

c. Predictors: (Constant), LCPUFA, maternal BMI, expressed breast fed, mixed feeding, formula fed

The relationship of infant feeding practices on five year old BMI-for-age percentile

The model summary for the relationship of infant feeding practices on BMI-for-age percentile at five years old is shown in Table 14. The analysis shows the change in variability of BMI-for-age percentile does not increase significantly with the addition of the confounding maternal variables. We removed those variables that have a change of >0.1 significance. Maternal PPVT, smoking status, LCPUFA supplementation during pregnancy and pre-pregnancy BMI were removed from the model.

Table 15 shows the model summary for the relationship of infant feeding practice on BMI-for-age percentile with maternal race as the confounding variable. There is no significant relationship between infant feeding practices at four months of age BMI-for-age percentile at five years of age.

Table 14: Model summary for the relationship of infant feeding practices on BMI-for-age percentile at five years old (n=86)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.109[a]	.012	.000	26.469	.012	1.006	1	84	.319
2	.265[b]	.070	.048	25.826	.059	5.234	1	83	.025
3	.285[c]	.081	.047	25.836	.011	.938	1	82	.336
4	.307[d]	.094	.050	25.805	.013	1.197	1	81	.277
5	.330[e]	.109	.053	25.760	.014	1.285	1	80	.260
6	.362[f]	.131	.041	25.922	.023	.667	3	77	.575

a. Predictors: (Constant), maternal PPVT
b. Predictors: (Constant), maternal PPVT, race
c. Predictors: (Constant), maternal PPVT, race, smoking
d. Predictors: (Constant), maternal PPVT, race, smoking, LCPUFA
e. Predictors: (Constant), maternal PPVT, race, smoking, LCPUFA, maternal BMI
f. Predictors: (Constant), maternal PPVT, race, smoking, LCPUFA, maternal BMI, mixed feeding, expressed breast fed, formula fed

Table 15: Model summary for the best fit relationship of infant feeding practices on BMI-for-age percentile at five years old (n=86)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.127[a]	.016	.004	26.411	.016	1.382	1	84	.243
2	.269[b]	.073	.027	26.113	.056	1.641	3	81	.186

a. Predictors: (Constant), race

b. Predictors: (Constant), race, mixed feeding, expressed breast fed, formula fed

Chapter 5

Discussion

This study analyzed the relationship between infant feeding practices and childhood body composition and anthropometrics. Considering the primary research question, this study did not find a statistically significant relationship between infant feeding practices at four months of age and childhood fat mass, fat free mass and percent body fat at the age of five years old. Maternal pre-pregnancy BMI did show a significant change in variability (p=0.028) in fat free mass at the age of five years old, but there were no other maternal characteristic that had a significant predictive relationship to fat mass and percent body fat.

In regard to the secondary research question, this study did not find a statistically significant relationship between infant feeding practices at four months of age and BMI-for-age percentiles at three, four and five years old. Maternal pre-pregnancy BMI (p=0.033) and LCPUFA supplementation during pregnancy (p=0.027) predicted BMI-for-age percentile at four years of age, but not at three or five years old.

The effect of infant feeding practices on five year old body composition

This study found similar results to those of recent research. Burdette et al (7) and Crume et al (8) also found no effect of infant feeding practice on childhood body composition. Burdette (7) found no difference in childhood body composition using DXA at the age of five for the infant feeding practices assessed in my study. A slight difference was seen in fat mass between the children who were breast fed compared to those who never breast fed, but this difference was not significant (7). Crume et al (8) found that more breast feeding in infancy predicted increased protection against subcutaneous adipose tissue and visceral adipose tissue, although the effect was not statistically significant.

Butte et al (3) found exclusively breast fed infants had lower fat free mass and higher fat mass and percent body fat at three months old compared to those who were fed mixed feeding of formula and human milk. However, these differences were not observed beyond the age of one year (3) analogous to Burdette (7), Crume (8) and this study, which did not finding significant relationships between infant feeding practices and childhood body composition.

The effect of infant feeding practices on childhood anthropometrics

Infant feeding practices did not have significant relationships on childhood weight status at three, four or five years of age. This is consistence with Butte et al (3), who showed that infants who formula fed increased in weight faster (grams per day) than breast fed infants from three months to six months of age, but there were no statistically significant differences in anthropometrics after one year old.

Bogen et al.'s (2) findings were not consistent with this study. We find no significant relationships between infant feeding at four months old and BMI-for-age percentiles at ages 3, 4 and 5. In contrast, Bogen (2) found an increase in obesity for those who had mixed feeding (human milk along with formula), suggesting a protective effect against the risk of obesity for those who breast fed without using formula. Bogen (2) stated that the relationship of infant feeding on childhood anthropometrics depended on specific factors, such as if the infant was fed with both human milk and formula, the duration of breast feeding, maternal smoking status and the race of the child.

Other research found that breast feeding may protect against the risk of childhood obesity (4, 5, 8). Gummer-Strawn (5), Hediger (4) and Crume (8) found that being overweight in childhood tended to be higher for those who never breast fed or had shorter duration of breastfeeding during infancy. Yet, Hediger et al (4) did not find a statistically significant difference with this trend nor did Grummer-Strawn (5) when maternal covariates were added to the analysis. Suggesting there are many confounding factors that affect childhood weight status.

Maternal pre-pregnancy BMI was found to be a confounding factor to childhood anthropometrics in this study (at four years old) and among published reports (2, 4, 7). Hediger et al (4) stated that maternal BMI was the strongest predictor for childhood BMI; having an obese mother triples the risk of being overweight in childhood.

Limitations

The main strength of this study was the large cohort of children that had been followed since infancy. Also, the infant feeding practices were collected prospectively, leading to more specific data collection than if the infant feeding practice data was collected retrospectively.

There were limitations to this study. The infant feeding data collection form was not designed to determine the specifics of infant feeding practices, such as to separate the difference between breast feeding by the breast and feeding expressed breast milk by the bottle. This flaw in the collection form lead to having dropped infants from the study. Another limitation was this study did not take into account physical activity and dietary habits during childhood. Physical activity and dietary habits during childhood may confound the results between infant feeding practices and childhood body composition and anthropometrics.

Chapter 6

Summary

The prevalence of childhood obesity is increasing in the United States and it's important to look at many different aspects that may be contributing to this health problem. There have been recent published reports that indicate a significant relationship between infant feeding practices and childhood body composition and anthropometrics. Although, there have also been recent research including this study that refute those relationships.

Breast feeding has been established as a protective factor for many health issues during infancy, although according to this study breast feeding does not have a significant protective effect against childhood obesity. Other published reports confirm these results, and suggest there are many other factors that influence a child's weight status. Maternal ethnicity, lifestyle habits and maternal weight status are among the most influential factors that have been found among the resent studies.

Many other factors affect a child's weight status, including physical activity, screen time and dietary habits. It may be more worthwhile for studies to focus the attention to the factors that occur throughout the childhood years to combat childhood overweight and obesity.

References

1. Section on Breastfeeding. Breastfeeding and the Use of Human Milk. Pediatrics 2012;129(3):e827-e41. doi: 10.1542/peds.2011-3552.
2. Bogen DL, Hanusa BH, Whitaker RC. The effect of breast-feeding with and without formula use on the risk of obesity at 4 years of age. Obes Res 2004;12(9):1527-35. doi: 10.1038/oby.2004.190.
3. Butte NF, Wong WW, Hopkinson JM, Smith EO, Ellis KJ. Infant feeding mode affects early growth and body composition. Pediatrics 2000;106(6):1355-66.
4. Hediger ML, Overpeck MD, Kuczmarski RJ, Ruan WJ. Association between infant breastfeeding and overweight in young children. JAMA 2001;285(19):2453-60.
5. Grummer-Strawn LM, Mei Z. Does breastfeeding protect against pediatric overweight? Analysis of longitudinal data from the Centers for Disease Control and Prevention Pediatric Nutrition Surveillance System. Pediatrics 2004;113(2):e81-6.
6. Gillman MW, Rifas-Shiman SL, Kleinman K, Oken E, Rich-Edwards JW, Taveras EM. Developmental Origins of Childhood Overweight: Potential Public Health Impact. Obesity 2008;16(7):1651-6. doi: 10.1038/oby.2008.260.
7. Burdette HL, Whitaker RC, Hall WC, Daniels SR. Breastfeeding, introduction of complementary foods, and adiposity at 5 y of age. Am J Clin Nutr 2006;83(3):550-8.
8. Crume TL, Bahr TM, Mayer-Davis EJ, Hamman RF, Scherzinger AL, Stamm E, Dabelea D. Selective protection against extremes in childhood body size, abdominal fat deposition, and fat patterning in breastfed children. Arch Pediatr Adolesc Med 2012;166(5):437-43. doi: 10.1001/archpediatrics.2011.1488.

9. Li R, Fein SB, Grummer-Strawn LM. Do Infants Fed From Bottles Lack Self-regulation of Milk Intake Compared With Directly Breastfed Infants? Pediatrics 2010;125(6):e1386-e93. doi: 10.1542/peds.2009-2549.

10. Carlson SE, Colombo J, Gajewski BJ, Gustafson KM, Mundy D, Yeast J, Georgieff MK, Markley LA, Kerling EH, Shaddy DJ. DHA supplementation and pregnancy outcomes. American J Clin Nutr 2013;97(4):808-15. doi: 10.3945/ajcn.112.050021.

11. Ogden Cl, Carroll M. D. Kit B. K. Flegal K. M. Prevalence of obesity and trends in body mass index among us children and adolescents, 1999-2010. JAMA 2012;307(5):483-90. doi: 10.1001/jama.2012.40.

12. Center of Disease Control and Prevention. CDC childhood obesity prevalence. February 19 2013. Internet: http://www.cdc.gov/healthyyouth/obesity/facts.htm (accessed 6/17/2013 2013).

13. Pediatric Nutrition Practice Group Academy of Nutrition and Dietetics. General Guidelines for Feeding Recommendations for Full-Term Infants.May 2013. Internet: http://www.nutritioncaremanual.org.proxy.kumc.edu:2048/content.cfm?ncm_content_id=91958 (accessed 6/17/2013 2013).

14. Center for Disease Control and Prevention. CDC prevalence of breast feeding in United States. June 6 2013. Internet: http://www.cdc.gov/breastfeeding/data/reportcard.htm (accessed 6/17/2013 2013).

Appendix A

Infant 24 hour dietary recall and feeding practice data collection form

24-Hour Dietary Recall Form

Visit: 4 MONTH

Random # Date of intake:__________ DOB: EDC:

Time	Food/Beverage	Ingredients/Preparation	Amount

Intake: Typical More than Usual Less than Usual Why? ______________________________

____

Recall: Reliable Unable to recall meals? Unreliable for other reasons? Why? ______________________

____

Vitamin/Mineral/Supplement Use? ____

Home / Daycare / Babysitter Number of people responsible for feeding ______________

Interviewer Initials: _______

INVESTIGATOR	PROTOCOL	RANDOM CODE	FORM ID
CARLSON	HSC #10186		E

INFANT FEEDING

Visit 1 (42 days of age*)

MO | DA | YEAR

☐ Breast Feeding — Date started ____ Stopped ____ Frequency ____

☐ Formula Feeding — Date started ____ Stopped ____ Frequency ____ Name ____

Visit 2 (120 days of age*)

MO | DA | YEAR

☐ Breast Feeding — Date started ____ Stopped ____ Frequency ____

☐ Formula Feeding — Date started ____ Stopped ____ Frequency ____ Name ____

Visit 3 (180 days of age*)

MO | DA | YEAR

☐ Breast Feeding — Date started ____ Stopped ____ Frequency ____

☐ Formula Feeding — Date started ____ Stopped ____ Frequency ____ Name ____

Visit 4 (275 days of age*)

MO | DA | YEAR

☐ Breast Feeding — Date started ____ Stopped ____ Frequency ____

☐ Formula Feeding — Date started ____ Stopped ____ Frequency ____ Name ____

Visit 5 (300 days of age*)

MO | DA | YEAR

☐ Breast Feeding — Date started ____ Stopped ____ Frequency ____

☐ Formula Feeding — Date started ____ Stopped ____ Frequency ____ Name ____

Visit 6 (365 days of age*)

MO | DA | YEAR

☐ Breast Feeding — Date started ____ Stopped ____ Frequency ____

☐ Formula Feeding — Date started ____ Stopped ____ Frequency ____ Name ____

Visit 7 (550 days of age*)

MO | DA | YEAR

☐ Breast Feeding — Date started ____ Stopped ____ Frequency ____

☐ Formula Feeding — Date started ____ Stopped ____ Frequency ____ Name ____

* age adjusted based on Estimated Date of Confinement (EDC)

Appendix B

Body composition consent form

CONSENT FORM
THE EFFECTS OF DHA ON PREGNANCY AND INFANT OUTCOME
(Addendum to HSC #11406)

You have enrolled in the University of Kansas HSC #11406 to evaluate whether taking a supplement of DHA can influence pregnancy and infant outcomes. As part of the study, we are interested in your child's growth, and we have measured his/her weight, length and head circumference at each visit. We have recently obtained an instrument that allows us to obtain information about your child's body fat and muscle mass. Now that your child is 5 years of age, we would like to measure his/her body fat and muscle mass. The results would add to the measures of growth we already have on your child. To complete the test, your child will wear a swimsuit and sit inside an egg shaped pod so the space they take up inside the pod can be measured. The procedure is simple, non-invasive and takes approximately 5 minutes to complete. We can show you the chamber if you would like to see it before you decide to have your child participate. We will keep the data confidential just as we have with all of your other personal information. If you agree to let us measure the body fat and muscle mass of your child, please check the "yes" box; if you do not agree, please check the "no" box.

Yes ☐

No ☐

____
Type/print Subject's Name

______________________ ________ ________
Signature of Subject Time Date

____
Type/Print Name of Person Obtaining Consent

______________________ ________
Signature of Person Obtaining Consent Date

____
Type/Print Name of Principal Investigator

______________________ ________
Signature of Principle Investigator Date

Appendix C

Infant anthropometric data collection form

INVESTIGATOR	PROTOCOL	RANDOM CODE	FORM ID
CARLSON	HSC #10186		F

ANTHROPOMETRICS

Study Visit 1 (42 days of age*) MO / DA / YEAR	Weight		g
	Length		cm
	Head circumference		cm
Study Visit 2 (120 days of age*) MO / DA / YEAR	Weight		g
	Length		cm
	Head circumference		cm
Study Visit 3 (180 days of age*) MO / DA / YEAR	Weight		g
	Length		cm
	Head circumference		cm
Study Visit 4 (275 days of age*) MO / DA / YEAR	Weight		g
	Length		cm
	Head circumference		cm
Study Visit 6 (365 days of age*) MO / DA / YEAR	Weight		g
	Length		cm
	Head circumference		cm
Study Visit 7 (550 days of age*) MO / DA / YEAR	Weight		g
	Length		cm
	Head circumference		cm

* age adjusted based on Estimated Date of Confinement (EDC)

Appendix D

Childhood anthropometric data collection form

INVESTIGATOR	PROTOCOL	RANDOM CODE	DOB
CARLSON	HSC #11406		

ANTHROPOMETRICS

2 Year Visit	Weight		g
MO / DA / YEAR	Length		cm
	Head circumference		cm
2.5 Year Visit	Weight		g
MO / DA / YEAR	Length		cm
	Head circumference		cm
3 Year Visit	Weight		g
MO / DA / YEAR	Length		cm
	Head circumference		cm
3.5 Year Visit	Weight		g
MO / DA / YEAR	Length		cm
	Head circumference		cm
4 Year Visit	Weight		g
MO / DA / YEAR	Length		cm
	Head circumference		cm

INVESTIGATOR	PROTOCOL	RANDOM CODE	DOB
CARLSON	HSC #11405		

ANTHROPOMETRICS PAGE 2

Visit	Date (MO / DA / YEAR)	Measure	Value	Unit
4.5 Year Visit		Weight		g
		Length		cm
		Head circumference		cm
5 Year Visit		Weight		g
		Length		cm
		Head circumference		cm
5.5 Year Visit		Weight		g
		Length		cm
		Head circumference		cm
6 Year Visit		Weight		g
		Length		cm
		Head circumference		cm