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Correlations between dietary indicators and cardiometabolic profiles in preschool children.

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Correlations between dietary indicators and cardiometabolic profiles in preschool children.

By

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DEDICATION

For Jacob and Olivia.

Thank you for being so understanding during all those hours I was working on many assignments. I want to show you that anything is possible and anyone can do it.

For Igor.

I’m very grateful for your patience and love.

For Mom and Dad.

Thank you for the support. If I needed anything, you were always there.

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LIST OF ABBREVIATIONS

ACF – Administration for Children and Families

BMI – Body Mass Index

BP – Blood Pressure

CDC – Center for Disease Control

CKD – Chronic Kidney Disease

CM – Cardiometabolic

CMD – Cardiometabolic Disease

CMS – Cardiometabolic Syndrome

cSBP – Central Systolic Blood Pressure

CVD – Cardiovascular Disease

DEXA – Dual-energy X-ray Absorptiometry

FVS – Food Variety Score

HDL – High Density Lipoprotein

HgbA1C – Glycated Hemoglobin

ICVH – Ideal Cardiovascular (metabolic) Health

IDDS – Individual Dietary Diversity Score

LDL – Low Density Lipoprotein

MetS – Metabolic Syndrome

NHANES – National Health and Nutrition Examination Survey

RBG – Random Blood Glucose

RBMI – Relative Body Mass Index

SAD – Sagittal Abdominal Diameter

SMBG – Self-monitoring Blood Glucose

T2DM – Type 2 Diabetes Mellitus

TAG – Triacylglycerols / Triglycerides

TC – Total Cholesterol

USDA – United States Department of Agriculture

WC – Waist Circumference

WHO – World Health Organization

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ABSTRACT

Background: Recent literature suggests preschool children regardless of income, age, ethnicity, and gender are subject to future cardiometabolic risk. Dietary intake, when analyzed can indicate diversity and lack of meeting adequate nutrient standards. A combination of anthropometric and blood analysis with dietary intake assessment can provide practitioners the knowledge for adequate early nutrition intervention and education.

Objectives: This descriptive, cross-sectional study describes the relationship between dietary intake and cardiometabolic indicators in preschool children. There is also a comparison of mean subject values and referenced national standards.

Study Sample: Four hundred seventy-one preschool children, between the ages of three and five, and parents were recruited via the Head Start program in seven different rural schools in Northeast Florida. Each parent was provided an Individual Dietary Diversity Score questionnaire. Children underwent blood sampling from a finger prick to assess lipids, glucose, hemoglobin and hematocrit. Body measurements including height, weight, waist circumference, sagittal abdominal diameter, and blood pressure were taken.

Statistical Analysis: Variables of interest were uploaded into SPSS software for quantitative analysis. Means and standard deviations were calculated for the continuous variables and frequencies and percent were calculated for the categorical variables. One-way analysis of variance was used to assess the relationship between the cardiometabolic variables as dependent variables and the dichotomous explanatory variables. One-sample t-tests were used to compare the mean values of the cardiometabolic variables with national standards by age and gender.

Results: Of the 471 subjects, 86 assessed via one-way ANOVA showed that lower diversity scores were significantly associated with lower blood triglycerides and higher hemoglobin (n = 137) and hematocrit % (n = 65) levels. Higher 100% fruit juice consumption was significantly associated with lower triglyceride levels. A higher intake of fresh vegetables was significantly associated with lower waist circumference and lower sagittal abdominal diameter. A higher soda consumption was significantly associated with greater waist circumference, greater sagittal abdominal diameter and higher triglyceride levels. When the cardiometabolic parameters in the study sample were compared with national standards, it was found that the height of study subjects was shorter (cm) than national standards for males and females. Waist circumference of 4 and 5-year-old males was smaller (cm) than national standards, BMI of 4-year-old females was lower than national standards, blood pressure in both male and female subject age groups was higher (mmHg) than national standards, and hematocrit % in both males and females was a higher percentage than national standards.

Conclusion: This study does support the belief that a diet with a higher intake of fresh vegetables, fruits and 100% fruit juice and a lower consumption of sugary beverages such as soda promotes a decrease in body composition, specifically measurements of adiposity around the abdominal area. Lowering abdominal adiposity decreases cardiometabolic risk.

INTRODUCTION

The dietary intake of preschool children in the United States has been examined in various studies assessing the status of nutritive value and inadequacies or overabundance of recommended guidelines. This thesis examines the comparisons of preschool children's dietary intake, related cardiometabolic risk factors including biomarkers and body composition assessment methods, within the Head Start Program, which is a resource program available to promote a healthier lifestyle for preschool children. The populations of preschool children researched in the literature review include rural low-income, overweight or obese, Hispanic, African American, and Caucasian.

Cardiometabolic syndrome (CMS) is not preferential to a specific population. Cardiometabolic syndrome may be used synonymously with cardiometabolic disease (CMD), and is also related to, but not identical to cardiovascular disease (CVD). Cardiometabolic syndrome is a combination of cardiometabolic risk factors or dysfunctions such as insulin resistance, impaired glucose tolerance, dyslipidemia, hypertension, and obesity or central adiposity.[1] Cardiometabolic risk factors are dysfunctions that can lead to developing cardiovascular diseases such as coronary heart disease, cardiac arrest, and stroke.[1] Regardless of the ethnicity, gender, income status, or cognitive development, children of preschool age are at a delicate stage of development and are prone to cardiometabolic health risks.[1,2,3,4,5]

LITERATURE REVIEW

Preschool Children's Dietary Habits in the U.S.

Children learn to try new foods and develop their own taste for what they know and enjoy. Preschoolers are at the age where introduced foods have the greatest resounding effect on a growing child's body composition, cognitive function, health and physiological ability.[6,7] Caregivers are the initial influencers of a child's diet. Children of preschool age typically do not feed themselves. Many parents unintentionally promote poor dietary habits for their children due to lack of knowledge of adequate nutrition for their child's growth. Children develop their food preferences and eating behaviors early in their lives and set patterns that affect weight and health outcomes later.[8] One study discussed the influence of parents on eating behaviors of children.[8] Breast feeding, genetic predisposition, beverage consumption, parental modeling dietary habits, mealtime practices, controlling and rewarding were examined. The findings indicated that children prefer foods that are sweet or salty and calorically dense instead of foods that are energy poor but rich in micronutrients. A continuous diet of these proportions results in health concerns as children become adults. The study suggests that parents can promote healthier eating practices by being a positive model and setting examples for their children rather than use approaches that criticize, reward, or refuse any dietary aspects. An assessment of the nutritional value and dietary composition in another study with 350 randomly selected preschool children ages 4 to 6 was conducted.[9] This study assessed three-day dietary intake and determined that the average diets were relatively high in processed foods and low in dietary content of fruits, vegetables and whole grains.

Influences of the preschool environment on dietary intake are strongly encouraged. While parents are the primary source for children's nutrition habits, many children attend preschools or daycares. Nutrition education programs are available to help daycare facilities and teachers to implement healthy eating habits in their curriculum. These programs have been successful with promoting an increase in preschoolers' heathier food intake.[6] However, it takes more than listening and learning to make an impact on these children. Preschools and daycares are encouraged to implement repeated taste exposure in the school. In a study that assessed teachers incorporation of nutrition and physical activity, instructors provided feedback on their nutrition education interactions with the children and reported that their biggest concerns are "picky eaters" and "food allergies".[10] This qualitative study provided insight to the desires of the preschool teachers who promote healthy eating habits. In the preschool setting of the Reggio Emilia inspired school the teacher follows the lead of the child, for example the children choose the foods that are made available to them, then determine and manage the setting of the meal. This preschool approach isn't a typical setting for most preschools and daycares in the U.S. However, they set an example for other schools to learn about how to implement nutrition education in a school by providing the tools for young children that influence the exploration and examination of healthy eating.

It is essential that healthy diets of preschool age children extend into adulthood. A risk factor of a diet poor in essential micronutrients include cardiometabolic disease.[11] Fruits and vegetables are associated with reducing the risk of these conditions. One meta-analysis found associations between fruit and vegetable intake and reduced risk of heart disease. Prior to this analysis, there were no specific recommendations for optimal levels and types of fruits and vegetables to prevent heart health issues. Researchers concluded that there was an inverse association between the intake of apples, pears, citrus fruits, green leafy vegetables, cruciferous vegetables, and salads and cardiometabolic disease (CMD).[11] The need to establish adequate intake early in life is paramount to prevention of heart disease. However, the Centers for Disease Control (CDC) reports that children are not consuming enough fruits and vegetables according to the National Health and Nutrition Examination Survey 2003 to 2010.[12] The daily requirements of fruits and vegetables for children ages two to five are 1 to 1½ cups of fruits and 1 to 1½ cups of vegetables. The statistics from 2007 to 2010 report that 6 out of 10 children are not meeting the fruit requirement intake and 9 out of 10 children are not meeting the vegetable requirement.[12] As children get older their intake of fruits and vegetables decreases. Consumption of potatoes, typically in the fried and chip form, is one third of the total vegetables that children eat. Children do consume more fruits than vegetables.

Individual Dietary Diversity Score

One of the measures used to assess diet quality in preschool children is to examine dietary diversity. Using an Individual Dietary Diversity Score (IDDS) provides an indicator for food groups whereas the Food Variety Score (FVS) provides an indicator for individual foods.[13] Using this method also provides insight as to the variety of household access to foods consumed.[14] The IDDS is a good indicator for predicting nutrient adequacy especially when portion size requirements are indicated. Micronutrient intake can be determined for adequacy.[13]

No research about dietary diversity of preschool children in the United States has been located to reference. Limited research has been conducted in countries geographically located in the Eastern Hemisphere. Dietary diversity of 1328 Chinese preschoolers from poor, rural and ethnic minority areas was studied.[15] The dietary diversity score (IDDS) was based on 9 food categories. The mean diversity score was 5.77 with a standard deviation of 1.22. In comparison to other similar dietary diversity studies from the China region, this study's results indicated significantly lower diversity scores. Contributing to the variation in the results study samples from other studies are children from urban Chinese, not rural, locations where the socioeconomic factors are different and the food supply offers more variety.[15] One study, from the Philippines represents the positive association with dietary diversity score of preschool children and the influence of home grown fruit and vegetable gardens.[16]

Cardiometabolic Risk Factors

Cardiometabolic risk factors can be detected in early childhood. A cross-sectional analysis from the National Health and Nutrition Examination Survey (NHANES 1999-2012) was conducted on subjects who were overweight or obese and within the ages of 3 to 19.[17] This analysis was designated to examine the prevalence of cardiometabolic risk factors among the 8579 eligible subjects with a body mass index (BMI) at the 85th percentile or higher with classified severities of obesity. The analysis indicated that by using three categories to classify obesity, identifying those with the greatest risk of cardiometabolic factors is a more calibrated approach. The variables used for cardiometabolic risk factors included total cholesterol, high density lipoprotein (HDL), systolic blood pressure, diastolic blood pressure, low density lipoprotein (LDL), triglycerides, glycated hemoglobin (HgbA1C), and glucose. This study concluded that the higher the classification of obesity among the sample population, the greater the prevalence of cardiometabolic risk, significantly among the subpopulation of boys and young men.[17] One Italian cohort study of cardiometabolic risk factors assessed a sample from a large population of children between the ages of 2 to 6 years old who were overweight or obese at the onset of the study.[3] Obesity rates were higher in the older children (age 5.8) than the younger subjects researched at 2-years-old. Researchers measured indicators for serum lipid levels, liver functions, uric acid, c-reactive protein, blood glucose and insulin levels. They used ultrasonographic methods to assess subcutaneous and visceral fat measures, hepatic steatosis levels and carotid artery thickness. Results indicated that of the 219 subjects studied, 39.3% had at least one metabolic risk factor. Hypertension was found in 13.2%, dyslipidemia in 25.1%, and nonalcoholic fatty liver disease in 31.1%. Fasting glucose and glucose intolerance were much lower at 3.2% and 2.7% respectively.[3]

An estimated 43 million children worldwide can be classified as overweight or obese.[4] Children with obesity do not all have the same metabolic response and cardiometabolic risk manifestations. Determining those who represent a higher risk requires specific factor clustering of cardiometabolic risk to allow for more focused screenings and interventions.[18] Ideally cardiometabolic risk factor clustering would replace the diagnosis of pediatric metabolic syndrome (MetS) based on the challenge pediatricians are presented with when defining MetS versus CMS in the younger pediatric population. MetS is more appropriate to use for the adult population.[19]

Indicators of Cardiometabolic Risk Factors

Blood Pressure

Systolic blood pressure is one standard indicator for cardiometabolic risk. Several studies and a meta-analysis reflect on the efficacy of brachial and central systolic blood pressure.[20,21,22,23] One meta-analysis reviewed 6 studies where central systolic blood pressure (cSBP) relates more strongly to cardiometabolic risk and vascular disease.[20] However, this method is invasive and unseemly to perform on younger study participants. Instead, brachial blood pressure is predominantly used as a variable to determine comparisons and relationships among other cardiometabolic risk factors.[21,23] In a study that measured cardiometabolic risk factors on children from ages 3 to 7, the variables among overweight and obese children that had a significant positive correlation with systolic blood pressure were waist circumference and BMI.[22]

There are cardiometabolic risks associated with diastolic blood pressure. One meta-analysis determined that systolic BP and diastolic BP could similarly predict stroke values, but systolic BP was more predictive of death due to ischemic heart failure.[23] Another meta-analysis, however, associated the similarity between both individual systolic and diastolic BP in the associations to determine stroke and ischemic heart disease.[24] Using diastolic BP as an indicator is also a predictive value when assessing children who are at cardiometabolic risk.

Lipids

From infancy to old age the leading cause of morbidity and mortality rates is CVD whether by genetics or dietary intake and physical inactivity. Determining the risk of CMS is assessed by using risk assessments. Biomarkers such as lipid profiles with total cholesterol, high density lipoprotein, low density lipoprotein, and triglycerides are included in risk assessment.[25] Elevated lipid cholesterol levels in children present a significant risk for future coronary heart disease. Experimental evidence has shown that dietary changes that include lower fat, lower saturated fat and cholesterol intake can result in improved lipid levels that can reduce vascular disease.[26]

Children who are predisposed to develop CVD due to genetic risk factors may benefit from early lipid profile screening.[27] Early onset child obesity is a risk factor where biometric assessment may be used to measure cardiovascular risk in preschool children. A review from

2018 encouraged lipid screening in children and adolescents.[28] This review noted that there is a reduced rate of screening for conditions contributing to arterial wall pathology such as obesity, hypertension, and prediabetes even though there is evidence that early detection and intervention can reverse cardiometabolic risk.

The American Heart Association has an ideal cardiometabolic health (ICVH) model which is a set of seven cardiometabolic health metrics for children and adults that indicate what are the ideal parameters of heart health. The seven metrics identify four ideal behavioral metrics as nonsmoking, being physically active, having normal body mass index (BMI), and eating a healthy diet. The three ideal health factors include normal blood pressure, total cholesterol, and plasma glucose levels. Ideal cardiometabolic health was defined as having all seven metrics of the behaviors and health factors. There is a low prevalence of ideal cardiometabolic health among adults and children in the United States.[26] One report on childhood cardiometabolic health urges screening as a targeted approach considering the current epidemic of childhood obesity with the subsequent increasing risk of hypertension and CVD in older children and adults. They assert that overweight children fall in a special risk category. Cholesterol screening should be required regardless of family history or other risk factors.[29,30]

Dyslipidemia is a disorder of lipoprotein metabolism affected by genetics or environmental disorder. The altered levels of total cholesterol (TC), low-density lipoprotein (LDL), non–high-density lipoprotein (non–HDL), triacylglycerols (TAG), high density lipoprotein (HDL), or a combination of these altered levels is measured to indicate dyslipidemia and its association with the risk of cardiometabolic disorders. Recommendations from the U.S. Preventative Services Task Force indicate that screening for dyslipidemia is necessary for children and adolescents. There are multivariate indicators for dyslipidemia including polygenic and environmental risks. They find that screening for dyslipidemia should begin at least by age six.[30]

Glucose Screening

Cardiometabolic risk variables include impaired glucose metabolism. Risk increases with a greater level of classified obesity.[19] An ongoing pattern of intake with a higher intake of sweets promotes early onset obesity which leads to inadequate glucose metabolism. Children are consuming inadequate amounts of dietary components that are high in nutritional value. Simple sugars increase blood glucose levels and impair insulin secretion, in individuals who have impaired glucose metabolism, which can lead to a regular imbalance of blood sugar levels and insulin resistance.[9] Children have a preference for consuming sweet foods. One Polish study evaluated the dietary intake of preschool children who attended public school and determined that the average diet was high in calorically dense foods and added sugar.[9] All 350 subjects self-reported their preference for sweets and sweetened foods. More than half consumed at least one serving of sweets per day, and 33.7% reported consuming sweets several times per week with a preference for candy, chocolate, biscuits, salty snacks, crisps, jelly sweets, nuts, crackers and fruit.

Whole blood glucose and HgbA1C are simple measures that can assess undiscovered metabolic risks. In a Chinese study with 213 children, glycated hemoglobin was examined in all subjects.[31] The 68 subjects with HgbA1C levels between 5.7-6.4% were given a glucose tolerance test. Of those children, 25.6% who completed the GTT were diagnosed prediabetic. Anthropometrics of the subjects and the glycated hemoglobin levels had a significant association (odds ratios, 1.58-1.90; all $P < 0.05$) with abdominal obesity and dyslipidemia, increasing the risk of cardiometabolic factors.

Whole blood glucose provides a one-time measure of a person's current glycemia. The measurement is sensitive to the most recent dietary consumption of complex and simple carbohydrates. When using a self-monitoring of blood glucose (SMBG) method to test whole blood glucose there is a limited amount of glycemic information provided, although it is useful when done regularly to achieve glycemic control.[32,33] The glycated hemoglobin test provides a two-to-three-month assessment of one person's glycemic level which is a better predictor of hyperglycemia and diabetes.[34]

Hemoglobin and Hematocrit

Hemoglobin, the protein found in red blood cells that carries oxygen throughout the body, and hematocrit, the measurement of the volume of red blood cells in total blood, are two biomarkers used to assess risk of CVD. Anemia is diagnosed when the body doesn't have an adequate amount of red blood cells to carry oxygen throughout the body and is linked to CVD, especially with those who have present heart conditions.[35] Assessing only hemoglobin levels is not a good indicator of cardiometabolic risk.[36] Part of the pediatric cardiometabolic risk factor screening should include hemoglobin and hematocrit. In a retrospective cohort study, children and adolescents between the ages of 11 to 21 were assessed for serum blood levels due to elevated casual blood pressure.[37] This study was focused on hematological measures and MetS. It found that of the 607 male subjects those who had MetS (n = 187) had higher levels of hemoglobin and hematocrit % than the other subjects without metabolic syndrome which can affect blood viscosity, limiting the flow and decreasing oxygen delivery.

Description of Body Composition Measures Associated with Cardiometabolic Risk Factors

Body Mass Index (BMI)

There is a correlation with body fat distribution and cardiovascular risk factors. Obesity can be assessed using BMI. A limitation with comparing studies' BMI analyses are due to the variability in cut-off parameters for obesity. Different populations have different body proportions and body fat distribution. Although the World Health Organization (WHO) has established the cut-off points for BMI, there may be differing cut-off points for BMI in various studies based on adaptation for the study population[38]. However, further assessment of nutritional status of individual subjects can aid with positively identifying obesity in children.[39] A systematic review and meta-analysis examined five studies that assessed the correlation of BMI with body fat (BF) measured by dual-energy X-ray absorptiometry (DEXA).[39] Child subjects among these five studies ranged in ages from 4 to 19 in both small and considerable sample size populations. This review reports that the amount of fat, or adiposity, in children is best measured with skinfold anthropometric methods. Another study, looking at visceral fat measurements, indicated that waist circumference is positively correlated to BMI, systolic and diastolic blood pressure, all of these are associated with cardiometabolic risk.[40] In a study by Kostecka,[9] 350 randomly selected preschool children ages 4 to 6 were assessed for relative body mass index (RBMI), which calculates the subjects' weight relative to the average BMI at the 50^{th} percentile. RBMI averages were 107.6% for girls and 103.3% for boys, indicating no excessive levels at any of the age groups. However, there were outliers in the boy's group with 3 subjects' RBMI ranging from 123.5-131.2% which identifies general obesity for these subjects.[9]

Earlier studies examined the relationship of dietary fat intake and its effects on body composition in preschool aged children. The methods of anthropometric assessment, to determine obesity, were typically obtained using BMI[41,42,43] or total body water.[44] BMI is a ratio of weight and height rather than a sole indicator for body composition. Multiple methods of body composition assessments are recommended for validity. More recently, the methods of assessing body composition include a combination of BMI, with waist circumference (WC) and sagittal abdominal diameter (SAD).[45]

Waist circumference

The gold standard method to assess total body composition is the dual-energy X-ray absorptiometry, but this method is both too complex and costly to use for research and regular individual assessments.[39] Alternatively, Burgos et al[40] found the strongest positive association for cardiometabolic risk assessment was between WC and BMI. Waist circumference measures both subcutaneous and visceral fat for a measurement of total abdominal fat. Measuring visceral obesity is an important indicator for the development of cardiometabolic disease and using both WC and BMI can be better predictors of risk rather than using only one method to ascertain risk.

Sagittal Abdominal Diameter

An alternative measurement of visceral abdominal obesity is the sagittal abdominal diameter (SAD). The use of this method is supported by studies that have shown that subcutaneous fat, when pushed to the side, is a better indicator of abdominal visceral fat. The method of SAD relies on the subject in a supine position to provide access so visceral fat may be measured. Visceral fat distribution is linked to inflammation which is a risk factor for CMD.[46] This anthropometric method was evaluated in a cross-sectional study with 948 Arab children between the ages of 10 to 17 years old.[47] The findings in this study conclude that BMI is a superior method to SAD and waist-to-height ratio. However, with SAD there were some associations that were significant within the parameters for cardiometabolic risk. The adipocytokines leptin and adiponectin had a more significant association with SAD than BMI. This could be interpreted that SAD could be used in a different way to predict cardiometabolic risk.

Appropriate Accessible Program for Preschoolers

Head Start

Programs have been created to promote healthy eating in preschool children. The Administration for Children and Families (ACF) initiated the Head Start Program over 50 years ago when the presidential administration believed there was a link to education performance and poverty levels. Promoting health education and providing resources for preschool aged children could combat poor performance in school related to insufficient diet and wellness.[48] This program reached out to preschools to implement the resources necessary to promote nutrition awareness and education. The National Head Start Impact Study is a longitudinal study from 2002 to 2006 that reviewed the efficacy of the program for reauthorization of continued services.[49] This study evaluated two primary goals. One goal was to assess the effectiveness of school readiness for the children involved in the program. The other goal was to determine which conditions allow the program to work best and which children benefited the most from the program. While there were positive impacts on preschool children due to the Head Start Program the impact study determined few statistically significant outcomes at the end of the participants' 1st grade year. Overall, there was a greater average of positive experiences for children, but not all children had the same quality of experience compared with the control group. The study concluded with a look at the potential need for expanding the program's length of time from one year of intervention to two years. It also provided insight to the need for adjusting the programs, centers, and classrooms for a more inclusive and positive impact on children's cognitive and physical health and wellness.[49] These programs are part of the considerable desire of lawmakers, healthcare providers and teachers to promote adequate health in preschool children to carry on proper habits to ensure long term results to avoid measured health issues including cardiovascular disease.[48]

Conclusion

The recent trend for obesity rates has shown a significant increase. The Center for Diseases Control (CDC) National Center for Health Statistics currently indicate the prevalence of obesity among preschool children is 13.9% among 2 to 5-year-olds.[50] The parental or guardian role plays a dominant factor as to what controls the nutritional and physical status of the child. Assessments, interventions, and education for all involved in the caregiving of children are necessary for prevention of childhood obesity.[51]

After examining the relationship among dietary intake, lipid levels and body composition of preschool children, dietary interventions and education may be determined from these findings. This review of literature indicates the importance of identifying the correlations between dietary indicators and cardiometabolic profiles in preschool children. It is important to examine how the preschool diet affects cardiometabolic biomarkers and body composition.

Project Rationale

The purpose of this project was to examine cardiometabolic profiles, anthropometrics and dietary indicators of preschool children attending seven schools in Northeast Florida and to compare these parameters to national standards.

Primary Objective

Describe the relationship of the IDDS and cardiometabolic indicators.

Primary Hypothesis

If the children in our study sample have a low diversity of intake their cardiometabolic indicators will be negatively affected and a high diversity of intake will positively affect cardiometabolic indicators.

Secondary Objective

Examine the relationship of fruit, vegetables, and 100% fruit juice intake and cardiometabolic indicators.

Secondary Hypothesis

A dietary intake high in fruits and vegetables of 6 or more per week will positively affect cardiometabolic indicators.

Tertiary Objective

Compare anthropometrics and biomarkers of the preschool subjects to the national reference. from the CDC.

Tertiary Hypothesis

Children from our study have similar levels of measures compared to national references.

METHODS

Study Design

The present study was a cross-sectional analysis of data collected from a quasi-experimental trial consisting of a multidisciplinary team of university researchers and faculty, graduate students and preschool educators. In the original trial, participants' schools were assigned to an intervention or control group within the seven of 14 Head Start Programs that were randomly selected and serviced over 1200 preschoolers in the community. Four of those seven schools were intervention schools. For this study, only data collected at the beginning of the trial were used.

Study Sample

Four hundred seventy-one participants, between the ages of 2 to 5, were originally recruited from the seven schools. Subjects and their parents were recruited during their schools' summer health screenings. Parents were provided with the option to consent to different components including (1) completing questionnaires regarding themselves and subjects about their knowledge of nutrition, (2) allowing children to have a blood finger prick taken in order to measure lipids, glucose, hemoglobin and hematocrit, (3) allowing their child's body measurements, blood pressure and child assessments to be taken. Families were given the option to consent to all measures, a few, or none at all. The families were instructed about the voluntary nature of the study and that no repercussion was intended from Head Start Program or the University of North Florida upon choosing not to participate.

Cardiometabolic Measurements

Anthropometric

Anthropometrics including height, weight, waist circumference (WC), and sagittal abdominal diameter (SAD) were assessed by the assistants to the researchers and researchers. Height was measured with a Harpendon stadiometer to the nearest 0.1 cm and weight was measured with a Seca Scale to the nearest 0.1 kg. The child was asked to remove shoes and any accessory clothing like a jacket. Waist circumference was measured at the top of the hip bone with a tape measure two times. In the event of differing measures, a third measure was obtained. The child was then asked to lay on a mat on the floor with their knees bent at a 90-degree angle and the Holtain-Kahn calipers were used to assess the sagittal abdominal diameter. The bottom of the calipers was slid under the subject's back and the child was told to take a deep breath in and exhale out. The top of the caliper was lowered at the level of the iliac crest. Two measurements were taken and if they differed by 0.1 cm, then a third measurement was obtained.

Blood Pressure

Blood Pressure (BP) was taken by a nurse practitioner (NP) at each of the sites. The child was instructed to sit for 10 minutes prior to the measurement. The NP measured the BP two times and a third measure was taken if the first two were significantly different. An average of all readings was used in data analysis.

Child Blood Analysis

Blood was obtained under aseptic conditions by a trained nurse practitioner. Blood was taken via finger prick on the middle or ring finger. A drop of blood was analyzed through the Cholestech LDX point-of-care device (POCD) (Alere, Inc., Waltham, MA) to measure total cholesterol, LDL-C, HDL-C, triglycerides, and glucose. A second drop of blood was used in the Hemopoint H2 machine (Alere, Inc., Waltham, MA) to analyze hemoglobin and hematocrit.

Nutrition Data

Individual Dietary Diversity Score (IDDS) was obtained that provided a parental recount of the prior week's food intake of food groups. Participants were provided a one-page survey consisting of a 16-item questionnaire on types of food consumed over one week (See Appendix A). They were asked to rank on a frequency scale from never to 2-3 times daily. Table 1 provides the categories of the 16 items broken down into seven groups for analysis.

Table 1. Seven Categories of IDDS

Category	Foods Providing Micronutrient Adequacy for Category
1	Dairy (milk, yogurt, cheese)
2	Grains and cereals (cooked cereals, whole grains)
3	Fruit and Vegetables (fresh fruit, canned or frozen fruit, fresh vegetables, canned vegetables)
4	Vitamin A rich vegetables (spinach, kale, collard greens)
5	Meat (poultry, fish, red meat, chicken)
6	Other (soda, dried fruits, prunes)
7	Fruit and vegetable juice

Statistical Analyses

Means and standard deviations were calculated for the continuous variables and frequencies and percent were calculated for the categorical variables. All cardiometabolic variables were treated as dependent variables, including: weight (kg), height (cm), WC (cm), BMI (kg/m^2), SAD (cm), systolic blood pressure (mm Hg), diastolic blood pressure (mm Hg), TC (mg/dL), high density lipoprotein (HDL) (mg/dL), triglycerides (mg/dL), low density lipoprotein (LDL) (mg/dL), glucose (mg/dL), hemoglobin (g/L), and hematocrit (%). The primary explanatory variable of interest was the IDDS. A dichotomous variable was created from the IDDS, consisting of two levels, high IDDS and low IDDS. High IDDS was calculated as

IDDS equal or greater than ‘6’ and low IDDS was calculated as IDDS lower than ‘6’. Dichotomous variables were also created for the other explanatory variables of interest: soda consumption, fruit juice consumption, and fresh vegetable consumption. For soda consumption, the categories created were ‘never’ or ‘at least once a week’, for fruit juice consumption and fresh vegetable consumption, the categories created were ‘low’ (5 or less times per week) and ‘high’ (6 or more times weekly).

In order to study the relationship between IDDS and the cardiometabolic variables, correlation coefficients were calculated (Spearman’s rho (rs)). One-way analysis of variance was used to assess the relationship between the cardiometabolic variables as dependent variables and the dichotomous explanatory variables: IDDS, soda intake, fruit juice intake, and fresh vegetable intake. All models presented are unadjusted. Normality of the dependent variables was checked by Shapiro-Wilk tests, and homogeneity of variances was checked with Levene’s test. Overall, the basic assumptions of the ANOVA test were met.

One-sample t-tests were used to compare the mean values of the cardiometabolic variables with national standards by age and sex. For the comparisons, age was transformed into a categorical variable with three levels: 3, 4, and 5 years. In the case of hemoglobin and hematocrit, age was used as a continuous variable for comparison with CDC data.

All statistical analyses were conducted using IBM SPSS, version 25, and *P*-values less than 0.05 were taken as statistically significant.

RESULTS

Completed dietary intake surveys, anthropometric measurements including height, weight, waist circumference (WC), and sagittal abdominal diameter (SAD), blood pressure, random blood sample to assess total cholesterol, HDL, LDL, triglycerides, TC/HDL, glucose, hemoglobin, and hematocrit were obtained from subjects (male: n=185, female: n=158, gender data missing: n=128). Although 471 subjects were enrolled, not everyone completed all measures. (See Tables 2 and 3). Ages of subjects were categorized by year (3.00: n=61, 4.00: n=111, 5.00: n=51, age data missing: n=248). The average age of subjects was 3.93 (*sd* 0.5928) years with a minimum age of 2.8 years and maximum age of 4.8 years. Ethnicities were categorized into four categories (White/Caucasian: n=88, Black/African American: n=54, Hispanic: n=25, and Other: n=13, ethnicity data missing: n=291). Incomplete or missing data were also included in the statistical analyses.

Table 2. Descriptive Statistics of Preschool Subjects' Age, Ethnicity, Gender

Preschool Subjects	**n**
Ages reported	223
2.01 - 3.00	61
3.01 - 4.00	111
4.01 - 5.00	51
Age not reported	248
Race reported	180
White/Caucasian	88
Black/African American	54
Hispanic	25
Other	13
Race not reported	291
Gender	343
Male	185
Female	158
Gender not reported	128

Table 3. Descriptive Statistics of Cardiometabolic Variables

Cardiometabolic Variables	**n**	**Mean**	**SD**
Weight (kg)	236	18.08	5.330
Meter height: turned from cm to m	234	1.023	0.060
BMI: ratios of weight in kg and height in meters at baseline interview	234	17.14	3.857
Sagittal Abdominal Diameter (cm)	228	11.56	1.40
Waist Circumference (cm)	232	50.89	7.00
Systolic Blood Pressure	224	85.60	9.37
Diastolic Blood Pressure	225	54.77	8.39
Total Cholesterol (mg/dL)	128	146.68	19.72
High Density Lipoproteins (HDL)	128	46.32	11.8
Triglycerides (mg/dL)	86	91.04	35.47
Low Density Lipoproteins (LDL)	86	84.95	17.93
TC/HDL	126	3.35	0.92
Glucose	126	93.15	14.05
Hemoglobin	137	12.02	1.73
Hematocrit %	65	38.69	2.71

Completed IDDS forms were taken from 190 subjects giving a response rate of 40.3%. Table 4 provides the diversity scores and the frequency of those scores for the subjects who responded. Table 5 provides the breakdown of the high diverse intake category from the low diverse intake category and the subjects who were non-respondents.

Table 4. Individual Dietary Diversity Scores

Score	**Frequency**	**Percent**
0	1	.5
1	1	.5
2	6	3.2
3	11	5.8
4	38	20.0
5	49	25.8

6	47	24.7
7	37	19.5
Total	190	100.0

Table 5. High and Low IDDS Categories

	Frequency	Percent
Non respondent (No data)	281	59.7
Low (1-5)	106	22.5
High (6-7)	84	17.8
Total	471	100.0

A Spearman's rho binary analysis indicated there were no significant correlations between IDDS and the cardiometabolic anthropometric variables weight, BMI, WC, and SAD. There were no significant correlations between IDDS and blood pressure, glucose, hemoglobin and hematocrit. There were also no significant correlations between IDDS and lipids (total cholesterol, HDL, LDL, triglycerides, TC/HDL).

One-way ANOVA was used to determine the relationship of the cardiometabolic variables with the IDDS categories (low: 1-5, high: 6-7, no IDDS). The subjects from the three different IDDS categories were compared with anthropometric variables, blood analysis, and blood pressure. Between-subjects factorial ANOVA was calculated comparing the participants who were high diversity, low diversity, or no survey information submitted and their individual cardiometabolic indicators. The main effect on cardiometabolic indicators was not significant for weight, waist circumference, BMI, sagittal abdominal diameter, systolic BP, diastolic BP, glucose, total cholesterol, HDL-C, and LDL-C ($P > .05$).

A significant main effect for the diversity score and triglycerides levels was found (F (2,83) = 5.461, P= .006). A pairwise comparison showed a significant difference in the means between the high and low categories. Low diversity category was associated with significantly lower mean triglycerides (*P* = .038). A significant main effect for the diversity score and hemoglobin was found (F (2,134) = 3.356, *P*= 0.038). The pairwise comparisons showed that low diversity score was associated with significantly higher mean hemoglobin (*P* = .018). There was a trend towards a significant association between low diversity score and high hematocrit % (F (2,62) = 2.874, *P* = 0.064). A pairwise comparison showed that low diversity group was associated with higher mean hematocrit % (*P* = .042) (Table 6).

Table 6. Table for estimates IDDS binary and CM indicators[1]

Variable	**n**	**Low IDDS**	**n**	**High IDDS**	**n**	**No IDDS**
Weight (kg)	102	18.4 (17.38, 19.46)	76	17.92 (16.71, 19.13)	58	17.68 (16.30, 19.07)
P-value		NS[2]		NS[3]		NS[4]
Waist Circumference (cm)	101	51.23 (49.86, 52.60)	73	51.34 (49.725, 52.95)	58	49.74 (47.92, 51.55)
P-value		NS		NS		NS
BMI (kg/m^2)	100	17.47 (16.71, 18.23)	76	16.86 (15.99, 17.74)	58	16.92 (15.92, 17.92)
P-value		NS		NS		NS
Sagittal Abdominal Diameter (cm)	98	11.61 (11.33, 11.89)	72	11.63 (11.30, 11.96)	58	11.38 (11.01, 11.74)
P-value		NS		NS		NS
Systolic Blood pressure (mmHg)	97	84.36 (82.48, 86.23)	73	86.49 (84.33, 88.65)	54	86.61 (84.10, 89.12)
P-value		NS		NS		NS
Diastolic Blood Pressure (mmHg)	98	54.13 (52.46, 55.80)	74	54.81 (52.88, 56.73)	53	55.90 (53.63, 58.18)
P-value		NS		NS		NS
Glucose (mg/dL)	61	92.62 (89.04, 96.20)	42	94.73 (90.42, 99.05)	23	91.69 (85.86, 97.52)
P-value		NS		NS		NS
Hemoglobin (g/dL)	67	12.40 (11.99, 12.82)	44	11.61 (11.10, 12.12)	26	11.72 (11.06, 12.38)
P-value		0.018[5]		0.018[5]		NS
Hematocrit (%)	34	39.44 (38.53, 40.34)	20	37.90 (36.72, 39.08)	11	37.81 (36.22, 39.40)
P-value		0.042[6]		0.042[6]		NS
Total Cholesterol (mg/dL)	62	146.93 (141.93, 151.93)	42	146.61 (140.54, 152.69)	24	146.16 (138.13, 154.19)
P-value		NS		NS		NS
HDL-Cholesterol (mg/dL)	62	45.41 (42.44, 43.39)	42	48.02 (44.40, 51.64)	24	45.66 (40.88, 50.45)
P-value		NS		NS		NS

Triglycerides (mg/dL)	46	80.76 (70.86, 90.65)	27	98.00 (85.08, 110.91)	13	113 (94.38, 131.61)
P-value		.038[7]		.038[7]		.003[7]
LDL-Cholesterol (mg/dL)	45	86.95 (81.61, 92.29)	27	82.14 (75.25, 89.04)	14	83.92 (74.35, 93.50)
P-value		NS		NS		NS

1. Values are mean (95% confidence interval)
2. The *P*-values in this column are for comparisons with High IDDS.
3. This *P*-value in this column are for comparisons with Low IDDS.
4. This *P*-value in this column are for comparisons with Low IDDS.
5. F (2,134) = 3.356, *P* = 0.038
6. F (2,62) = 2.874, *P* = 0.064 (trending toward significance (Parwise)
7. F (2,83) = 5.461, *P* = 0.006

Table 7 shows the associations between consumption of fruit juice and the cardiometabolic indicators. There were no significant associations between the consumption of fruit juice and any of the cardiometabolic indicators except for triglycerides. There was a significant relationship between fruit juice category and triglyceride levels (F (2,83) = 3.895, *P* = .024). Although there were no statistically significant differences in triglyceride levels between those in the low and those in the high fruit juice categories, there was a significant difference (P = .007) in triglyceride levels between those in the low fruit juice category and those who categorized as non-respondents of the dietary survey (Table 6).

Table 7. Fruit juice and cardiometabolic indicators[1]

Variable	n	Low FJ	n	High FJ	n	No Dietary Survey
Weight (kg)	93	18.190 (17.10, 19.28)	93	18.414 (17.28, 19.54)	57	17.408 (16.01, 18.80)
P-value		NS[2]		NS[3]		NS[4]
Waist Circumference (cm)	91	51.20 (49.75, 52.64)	84	51.33 (49.83, 52.84)	57	49.75 (47.92, 51.58)
P-value		NS		NS		NS
BMI (kg/m^2)	91	17.07 (16.27, 17.86)	86	17.57 (16.75, 18.39)	57	16.6 (15.59, 17.61)
P-value		NS		NS		NS
Sagittal Abdominal Diameter (cm)	89	11.58 (11.29, 11.87)	82	11.65 (11.35, 11.96)	57	11.38 (11.02, 11.75)

P-value		NS		NS		NS
Systolic Blood pressure (mm/Hg)	89	85.49 (83.53, 87.45)	82	84.95 (82.90, 86.99)	53	86.77 (84.23, 89.31)
P-value		NS		NS		NS
Diastolic Blood Pressure (mm/Hg)	91	55.31 (53.59, 57.04)	81	53.42 (51.58, 55.25)	53	55.90 (53.64, 58.17)
P-value		NS		NS		NS
Glucose (mg/dL)	57	93.38 (89.67, 97.09)	46	93.60 (89.48, 97.73)	23	91.69 (85.85, 97.53)
P-value		NS		NS		NS
Hemoglobin (g/dL)	63	12.32 (11.89, 12.75)	48	11.79 (11.30, 12.28)	26	11.72 (11.05, 12.39)
P-value		NS		NS		NS
Hematocrit (%)	33	38.75 (37.80, 39.70)	21	39.04 (37.85, 40.23)	11	37.81 (36.17, 39.46)
P-value		NS		NS		NS
Total Cholesterol (mg/dL)	58	147.24 (142.07 152.40)	46	146.26 (140.46, 152.06)	24	146.16 (138.13, 154.19)
P-value		NS		NS		NS
HDL-Cholesterol (mg/dL)	58	46.51 (43.42,49.61)	46	46.41 (42.94, 49.88)	24	45.66 (40.85, 50.47)
P-value		NS		NS		NS
Triglycerides (mg/dL)	41	82.75 (72.09, 93.41)	32	92.75 (80.68, 104.81)	13	113 (94.06, 131.93)
P-value		NS		NS		.007[5]
LDL-Cholesterol (mg/dL)	40	86.90 (81.22, 92.57)	32	82.96 (76.62, 89.31)	14	83.92 (74.33, 93.52)
P-value		NS		NS		NS

1. Values are mean (95% confidence interval)
2. The *P*-values in this column are for comparisons with High FJ.
3. This *P*-value in this column are for comparisons with Low FJ.
4. This *P*-value in this column are for comparisons with Low FJ.
5. F (2,83) = 3.895, *P* = .024

In Table 8 it was found that higher intake of fresh vegetables was significantly associated with lower waist circumference (F (2,229) = 5.718, *P* = .004) and lower sagittal abdominal diameter (F (2,225) = 2.944, *P* = .055). A pairwise comparison indicated that those with high intake of fresh vegetables had significantly lower waist circumference (*P* = .003) and sagittal abdominal diameter (*P* = .031) compared with those with low intake of fresh vegetables.

Table 8. Fresh vegetables and cardiometabolic indicators[1]

Variable	n	Low FV	n	High FV	n	No Dietary Survey
Weight (kg)	86	18.84 (17.71, 19.97)	91	17.58 (16.48, 18.67)	59	17.74 (16.38, 19.11)
P-value		NS[2]		NS[3]		NS[4]
Waist Circumference (cm)	83	52.93 (51.45, 54.42)	90	49.76 (48.33, 51.18)	59	49.74 (47.98, 51.50)
P-value		.003[5]		.003[5]		.007[5]
BMI (kg/m^2)	85	17.60 (16.78, 18.43)	90	16.88 (16.08, 17.69)	59	16.85 (15.86, 17.84)
P-value		NS		NS		NS
Sagittal Abdominal Diameter (cm)	82	11.85 (11.55, 12.16)	87	11.39 (11.10, 11.68)	59	11.39 (11.03, 11.74)
P-value		.031[6]		.031[6]		.050[6]
Systolic Blood pressure (mm/Hg)	80	85.62 (83.55, 87.69)	89	84.97 (83.01, 86.94)	55	86.56 (84.06, 89.06)
P-value		NS		NS		NS
Diastolic Blood Pressure (mm/Hg)	82	55.15 (53.32, 56.98)	88	53.98 (52.22, 55.75)	55	55.45 (53.22, 57.68)
P-value		NS		NS		NS
Glucose (mg/dL)	53	93.13 (89.28, 96.97)	49	93.81 (89.81, 97.81)	24	91.87 (86.15, 97.59)
P-value		NS		NS		NS
Hemoglobin (g/dL)	54	12.38 (11.92, 12.85)	56	11.84 (11.38, 12.30)	27	11.767 (11.01, 12.32)
P-value		NS		NS		NS
Hematocrit (%)	26	39.42 (38.37, 40.47)	28	38.35 (37.34, 39.37)	11	37.81 (36.20, 39.43)
P-value		NS		NS		NS
Total Cholesterol (mg/dL)	54	144.68 (139.36, 150.00)	49	149.38 (143.80, 154.97)	25	145.72 (137.89, 153.54)
P-value		NS		NS		NS
HDL-Cholesterol (mg/dL)	54	47.37 (44.17, 50.56)	49	45.77 (42.42, 49.13)	25	45.12 (40.42, 49.81)
P-value		NS		NS		NS
Triglycerides (mg/dL)	36	87.02 (75.41, 98.63)	36	88.25 (76.64, 99.85)	14	108.57 (89.95, 127.18)
P-value		NS		NS		NS
LDL-Cholesterol (mg/dL)	36	83.13 (77.15, 89.12)	35	87.02 (80.95, 93.10)	15	84.46 (75.19, 93.74)
P-value		NS		NS		NS

1. Values are mean (95% confidence interval)
2. The *P*-values in this column are for comparisons with High FV.
3. This *P*-value in this column are for comparisons with Low FV.
4. This *P*-value in this column are for comparisons with Low FV.
5. $F(2,229) = 5.718$, $P = .004$
6. $F(2,225) = 2.944$, $P = .055$

In Table 9 we found significant associations between soda consumption and both waist circumference (F (2,229) = 3.545, *P* = .030) and sagittal abdominal diameter (F (2,225) = 4.913, *P* = .008). Those in the high category of soda consumption had significantly higher waist circumference compared with those in the low category of soda consumption (*P* = .028) and the non-respondents (*P* = .031). Similarly, those in the high category of soda consumption had a higher mean SAD compared with those in the low category (*P* =.004) and with the non-respondents (*P* = .027).

Table 9. Soda Consumption and Cardiometabolic Indicators[1]

Variable	**n**	**Once or More Weekly**	**n**	**Never Weekly**	**n**	**No Dietary Survey**
Weight (kg)	111	18.59 (17.60, 19.59)	66	17.62 (16.32, 18.91)	59	17.63 (16.26, 19.00)
P-value		NS[2]		NS[3]		NS[4]
Waist Circumference (cm)	109	52.18 (50.87, 53.48)	64	49.76 (48.05, 51.46)	59	49.74 (47.96, 51.52)
P-value		.028[5]		.028[5]		.031[5]
BMI (kg/m^2)	110	17.46 (16.74, 18.19)	65	16.81 (15.86, 17.75)	59	16.90 (15.91, 17.89)
P-value		NS		NS		NS
Sagittal Abdominal Diameter (cm)	105	11.86 (11.60, 12.13)	64	11.23 (10.89, 11.57)	59	11.36 (11.01, 11.72)
P-value		.004[6]		.004[6]		.027[6]
Systolic Blood pressure (mm/Hg)	106	85.74 (83.94, 87.54)	63	84.58 (82.25, 86.92)	55	86.47 (83.97, 88.96)
P-value		NS		NS		NS
Diastolic Blood Pressure (mm/Hg)	108	54.53 (52.94, 56.13)	63	54.19 (52.10, 56.27)	54	55.92 (53.67, 58.17)
P-value		NS		NS		NS
Glucose (mg/dL)	63	92.25 (88.75, 95.75)	39	95.84 (91.39, 100.29)	24	91.16 (85.49, 96.84)
P-value		NS		NS		NS
Hemoglobin (g/dL)	66	11.98 (11.56, 12.41)	44	12.22 (11.70, 12.74)	27	11.78 (11.11, 12.44)
P-value		NS		NS		NS
Total Cholesterol (mg/dL)	64	146.01 (141.10, 150.92)	39	148.28 (141.99, 154.57)	25	145.92 (138.06, 153.77)
P-value		NS		NS		NS

HDL-Cholesterol (mg/dL)	64	45.15 (42.23, 48.08)	39	48.33 (44.58, 52.08)	25	46.16 (41.48, 50.84)
P-value		NS		NS		NS
Triglycerides (mg/dL)	51	85.05 (75.44, 94.67)	22	91.95 (77.32, 106.58)	13	113.00 (93.96, 132.03)
P-value		NS		NS		.011[7]
LDL-Cholesterol (mg/dL)	50	84.74 (79.63, 89.84)	22	86.09 (78.39, 93.78)	14	83.92 (74.28, 93.57
P-value		NS		NS		NS

1. Values are mean (95% confidence interval)
2. The *P*-values in this column are for comparisons with Never.
3. This *P*-value in this column are for comparisons with Once.
4. This *P*-value in this column are for comparisons with Once.
5. F (2,229) = 3.545, p = .030
6. F (2,225) = 4.913, p = .008
7. F (2,83) = 3.406, p = .038

Table 10 shows a comparison of cardiometabolic indicators between the children in the present study and national reference values.

Table 10. Comparison of Subject Mean with Reference Values[1,2,3,4,5]

Variable	**n**	**Age 3 (SE)**	**n**	**Age 4 (SE)**	**n**	**Age 5 (SE)**
Weight (kg) (males)	28	16.8 (0.97)	56	17.91 (0.56)	27	20.1 (1.56)
Reference value		16.2		18.5		21.2
P-value		NS[5]		NS[5]		NS[5]
Weight (kg) (females)	32	15.42 (0.47)	50	17.69 (0.51)	23	21.67 (1.42)
Reference value		15.70		17.70		21.10
P-value		NS		NS		NS
Height (cm) (males)	28	96.64 (0.66)	56	103.26 (0.61)	27	106.97 (1.05)
Reference value		98.90		106.20		113.70
P-value		.002		.000		.000
Height (cm) (females)	31	97.49 (0.82)	50	102.37 (0.70)	23	108.68 (1.00)
Reference value		98.70		105.00		112.60
P-value		NS		.000		.001
Waist Circumference (cm) (males)	27	49.52 (0.91)	55	50.75 (0.82)	27	50.81 (0.76)
Reference value		50.50		52.70		54.80
P-value		NS		.022		.000
Waist Circumference (cm) (females)	30	49.59 (0.89)	50	52.64 (1.06)	23	53.50 (2.26)

Reference value		50.20		52.10		55.60
P-value		NS		NS		NS
BMI (kg/m^2) (males)	27	17.97 (0.90)	56	16.71 (0.44)	27	17.38 (1.12)
Reference value		16.50		16.30		16.30
P-value		NS		NS		NS
BMI (kg/m^2) (females)	31	16.26 (0.35)	50	16.75 (0.30)	23	18.15 (0.97)
Reference value		16.00		16.00		16.50
P-value		NS		.017		NS
Systolic Blood Pressure (mm/Hg) (males)	24	83.88 (1.76)	53	86.83 (1.34)	27	88.11 (1.87)
Reference value		91.00		93.00		95.00
P-value		.001		.000		.001
Systolic Blood Pressure (mm/Hg) (females)	29	83.52 (1.34)	50	84.44 (1.26)	23	86.48 (2.54)
Reference value		89.00		91.00		93.00
P-value		.000		.000		.018
Diastolic Blood Pressure (mm/Hg) (males)	24	53.92 (1.92)	54	54.33 (1.15)	27	53.89 (1.48)
Reference value		46.00		50.00		53.00
P-value		.000		.000		NS
Diastolic Blood Pressure (mm/Hg) (females)	29	54.07 (1.32)	50	55.90 (1.18)	23	53.22 (2.01)
Reference value		49.00		52.00		54.00
P-value		.001		.002		NS
Hemoglobin (g/dL) (males)[6]	71	12.05 (0.23)		n/a		n/a
Reference value		12.35				
P-value		NS				
Hemoglobin (g/dL) (females)[6]	63	12.00 (0.19)		n/a		n/a
Reference value		12.07				
P-value		NS				
Hematocrit (%) (males)[6]	33	38.81 (0.39)		n/a		n/a
Reference value		37.00				
P-value		.000				
Hematocrit (%) (females)[6]	31	38.58 (0.57)		n/a		n/a
Reference value		37.00				
P-value		.010				
Total Cholesterol (mg/dL) (males)	24	144.83 (3.16)	31	143.93 (3.41)	16	145.87 (5.92)
Reference value		144.80		143.90		145.90
P-value		NS		NS		NS

Total Cholesterol (mg/dL) (females)	16	144.43 (4.73)	27	151.37 (4.18)	12	153.91 (5.94)
Reference value		144.40		151.40		153.90
P-value		NS		NS		NS

1. Values are mean (Standard Error Mean)
2. Cited from CDC: Anthropometric Reference Data for Children and Adults: United States 2007-2010.[52]
3. Cited from Hematological and Iron-Related Analytes— Reference Data for Persons Aged 1 Year and Over: United States, 1988–94. NHANES III (1988-1991)[53]
4. Cited from Total Serum Cholesterol Levels of Children 4-17 Years: United States, 1971-74. Abraham, S., Johnson, C. L., Carroll, M. D. 1978. 38 pp. P88-226386. PC A03 MF A01.[54]
5. The *P*-values in this column are for comparisons with national reference values (Test Values) for age group.
6. Mean hemoglobin and hematocrit standards were combined in one category age group of 3 to 5-year-olds.

Three, four, and five-year-old males and females in the study had similar weights compared to the reference weights reported by the CDC in 2007-2010.[51] A single-sample t-test compared the mean height of males ages three, four and five of the samples to standard values. In the three-year-old group, a significant difference was found $t(27) = -3.397$, $P = .002$. The sample mean of 96.64 ($SE = 3.51$) was significantly lower than the national mean. The four and five-year-old groups also had significantly lower means than the national value [$t(55) = -4.788$, $P = .000$; $t(26) = -6.378$, $P = .000$] respectively.

Females ages four and five were also found to have significantly lower height than the national standard values [$t(49) = -3.740$, $P = .000$; $t(22) = -3.895$, $P = .001$] respectively. The three-year-old group had similar mean values to the national mean values.

There was a significant difference in BMI of the 4-year-old females compared to national reference values. The sample mean of 16.75 was significantly higher than the national mean of 16 ($t(49) = 2.463$, $P = .017$). All other male and female groups had BMIs that were comparable to national reference values.

With the exception of five-year-old male and female diastolic blood pressure, all age groups indicated significantly lower systolic and higher diastolic blood pressure than the references mean values as shown in Table 10.

There were no differences between our sample and the national reference values for hemoglobin and total cholesterol, whereas hematocrit values for both males, 38.81% (*SE* = 2.24), and females, 38.58% (*SE* = 3.21), were significantly higher than the referenced national standard mean value for preschoolers ages three to five [$t(32) = 4.658$, $P = .000$ for males and; $t(30) = 2.740$, $P = .010$ for females].

Table 11. Glucose frequency values.

Glucose Level (mg/dL)	**Frequency**	**Glucose Level (mg/dL)**	**Frequency**
101	2	112	4
102	2	114	1
103	3	116	2
104	3	118	1
105	3	119	1
106	1	123	1
108	1	126	1
109	3	127	1
110	1	132	1
		Total	**33**

There were a total of 126 preschoolers who had random whole blood glucose measurements. Table 11 shows data for thirty-three out of the 126 subjects (26.2%) who had levels higher than 100 mg/dL.

DISCUSSION

The primary objective of this thesis was to describe the relationship of the Individual Dietary Diversity Score and cardiometabolic indicators. There is evidence that a diet that is diverse is important to attain the nutrient balance required to prevent consequences of cardiometabolic risk.[55,56] Dietary diversity is an indicator for predicting how well children in our study, from rural geographic locations, meet their nutritional requirements.[13] Our results are similar to a study by Bi et al,[15] who found that children living in a rural area of China had a lower dietary diversity than children from urban locations. The rural Chinese study had nine food categories similar to our IDDS including a category for Vitamin A-rich foods. Socioeconomic factors affected the IDDS scores but the scores of the rural Chinese subjects were not compared to cardiometabolic factors. The preschool children in our analysis were from rural locations in the U.S. Our IDDS score was based on seven categories or food groupings. Scoring the categories was set at a low / high binary diversity intake with a score of 0 through 5 as 'low' diversity and 6 through 7 as 'high' diversity. This binary analysis allowed for a more balanced response of reported dietary intake, especially considering 59.7% of the total subjects lacked dietary survey participation. It is uncertain that a stronger response rate for our analysis would determine a lower dietary diversity score of our rural preschool subjects' diets for comparison. Geography can play a role in lack of diversity due to limited access to imported foods. Evidence from an evaluation of eleven countries' demographic and health surveys found an association between dietary diversity and nutritional status based on socioeconomic factors.[57] Quality of intake is dependent on socioeconomic status, which is reflected in intake diversity.

There were some significant relationships of cardiometabolic risk and lower dietary diversity in this analysis. A Filipino study addressed fruit and vegetable intake and the dietary diversity of children who have vegetable gardens.[17] Preschool children who lived in a rural province that had home vegetable gardens had a higher dietary diversity score than those without home gardens. In comparison, the preschool subjects in this analysis, who had higher fruit and vegetable intake and lower soda consumption, had significantly decreased cardiometabolic indicators. These comparisons address the secondary objective to determine the effects of fruit and vegetable intake on cardiometabolic indicators. Giving children the capacity of exposure to explore foods can aid with increasing diet diversity.[8]

Anthropometric measures discussed in the literature explained why each was useful for the measurement of cardiometabolic risk.[41,42,44,45] No single measure can examine the risk. A combination of measurements provide validity for measuring cardiometabolic risk according to studies that researched the comparisons of anthropometric assessments with dietary intake.[41,44,45] When we examined the cardiometabolic indicators with vegetable dietary intake, both SAD and WC, which measure abdominal fat, are significantly associated with dietary intake. These findings provide substance to the recommendation that multiple methods of assessment are beneficial.

Cardiometabolic biomarkers, researched for comparison with dietary intake, were useful in this study because there were significant findings for lipid profiles.[30] An adult study found a diet with lower diversity was prevalent with subjects who had MetS and subjects with higher triglycerides and blood pressure.[58] Pediatric dietary diversity has been examined but there are no associations or comparisons for determining the effects of dietary diversity on cardiometabolic lipid biomarkers. The Tehran Lipid and Glucose study provided data for an assessment on dietary diversity scores in adolescents ages 10 to 18, however the researchers did not use the lipid biomarkers from the original trial to compare to the dietary diversity scores.[59] In our analysis, significant relationships were found among diversity scores and triglyceride levels, hemoglobin and hematocrit percentage. These results indicate that the lower the diversity score the more significantly lower mean levels of triglycerides, and significantly higher mean hemoglobin levels and higher mean hematocrit percentage. Addressing the unusual results for the low triglyceride levels with the lower dietary diversity may be indicative of the child's most recent dietary intake since the blood was taken from a random, one-time fingerstick rather than requesting children to do a fasting blood analysis taken via venipuncture. Hemoglobin and hematocrit levels typically trend together. Both levels are either high or low together. Research supports that higher levels of hemoglobin and hematocrit may cause an increase in blood viscosity limiting blood flow and oxygen delivery.[37] During the initial trial and assessment of these levels, the blood analysis device Hemopoint H2 did not provide a reading for all subjects. An error message for hematocrit (n = 65) was provided instead reading approximately half of the total subjects who were assessed for hemoglobin (n = 137) (Table 3).

A caveat to this analysis is the significance of a diverse diet. Diverse does not essentially mean "healthful" if the categories chosen represent foods that are calorically and nutrient dense rather than rich in essential vitamins and minerals that reduce cardiometabolic risk. Survey analyses use numbers to represent significance without looking at individual foods or the overall percentage of food categories that are not "healthful". This analysis does support the research studies that implicate a diet with a higher intake of fresh vegetables, fruits and 100% fruit juice and a lower consumption of sugary beverages such as soda is associated with a decrease in body composition, specifically measurements of adiposity around the abdominal area.[11,60] A review of studies concluded that consuming a specialized diet, influenced by the Mediterranean region diet, which contains a proportionately larger amount of fruits and vegetables has beneficial effects on cardiometabolic risk factors.[60] Our analysis compared the high and low intake of fresh vegetables to cardiometabolic indicators finding that those with a higher intake vegetables are associated with a lower waist circumference. Our findings are supported by a study that examined preschool children who followed a Mediterranean-based diet.[61] Those who adhered to a high Mediterranean dietary pattern were significantly associated with a lower waist circumference. Lowering abdominal adiposity decreases cardiometabolic risk as indicated in studies that examined anthropometric indicators.[46,47] Assessing cardiometabolic risk in the pediatric population, a study found that there are stronger correlations with measuring total cardiometabolic risk and SAD than other anthropometric methods.[46]

When screening for diabetes in the pediatric population a fasting plasma blood glucose level that defines prediabetes is ≥ 100 mg/dL but ≤ 125 mg/dL. A random plasma glucose level of ≥ 200 mg/dL in via fingerstick may be used to extrapolate a diagnosis of diabetes with additional glucose assessments.[62] None of our subjects measured within these parameters. There is evidence that random blood glucose (RBG) measures are an effective method to determine cardiometabolic risk. Bowen et al,[63] examined RBG via finger-stick in a cross-sectional NHANES study with 13,792 participants who were undiagnosed with diabetes. The study's aim was to determine if RBG ≥ 100 mg/dL is a good indicator for T2DM. The study concluded that there is a stronger association with undiagnosed diabetes by using a single measurement of RBG ≥ 100 mg/dL than traditional U.S. screening strategies, with recommendations to consider single RBG assessment added to U.S. screening guidelines.

Limitations to this analysis include incomplete data provided by the caregivers and subjects declining assessment methods. Another limitation is a small subject population. Also, blood analysis was conducted from a one-time random finger stick, rather than fasting blood. Some of the blood analysis during the assessments resulted in an "error" message from the Hemopoint H2 machine. Additionally, our data poses only a cross-sectional set of information rather than using the prospective data that was originally obtained in the complete trial. A strength of this comparative analysis is that it adds to the limited research about dietary diversity in American preschool children. More research is recommended to further analyze body composition methods and dietary diversity promotions of preschool children.

We've adopted a laissez-faire attitude about children's health over several decades that needs to be adjusted. A more assertive demonstration is needed for those who are not old enough to know better how to make good choices for themselves. Caregivers and practitioners should be pragmatic about knowing how to prevent future cardiometabolic disorders.

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APPENDIX A

IDDS SURVEY

Healthy Habits for Life: An interdisciplinary evaluation of a Head Start nutrition curriculum

Individual Dietary Diversity Score (IDDS): (Pulled from Ann. N.Y. Acad . Sci.): The IDDS is used for infants and young children to assess individual access to seven food groups. Parents are asked to report on their children's a variety of foods and to dietary quality. The recall period is one week. Validity was tested in multip le countries and result in either 8 or 16 food groups. The 8 food groups are 1) grains, roots, tubers 2) legumes and nuts 3) dairy 4) flesh foods 5) eggs 6) vitamin A-rich fruits/vegs 7) other fruits and vegetables 8) fats and oils (USAID, 2006). The 16 food groups are: 1) Cereals 2) white roots and tubers 3) vitamin A rich vegetables and tubers 4) dark green leafy vegetables 5) other vegetables 6) vitamin A rich fruits (dark yellow or orange) 7) other fruits 8) organ meat 9) flesh meat 10) eggs 11) fish and seafood 12) legumes, nuts , seeds 13) milk and milk products 14) oils and fats 15) sweets 16) spices, condiments and beverages (Found in the guidelines for measuring household and individual diversity).

Prompt for families: Thinking over the past week, how often does your child have the following foods:

	NEVER	At least 1 time in the past week	2-5 times in the past week	6 or more times, but not daily	At least one time daily	2-3 times daily
Fruit juice (apple, orange) 100%						
Vegetable juice (tomato, carrot)						
Milk						
Soda						
Cooked cereal (oatmeal, grits)						
Whole grains (cereal, bread, brown rice)						
Fresh fruit						
Canned or frozen fruit						
Fresh vegetables						
Canned or frozen vegetables						
Leafy vegetables (spin ach, kale, collard greens)						

Red meat (beef, pork)						
Fish or chicken						
Yogurt						
Cheese						
Dried fruit (raisins, prunes)						