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Metabolic Syndrome In Obese African American Adolescents

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METABOLIC SYNDROME IN OBESE AFRICAN AMERICAN ADOLESCENTS

by

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DEDICATION

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LIST OF ABBREVIATIONS

1,25 D3:1,25-dihydroxyvitamin D

25-D: 25-hydroxy vitamin D

AAA: African American adolescents

BFFQ: block food frequency questionnaire

BIA: bioimpedance analysis

CDC: Center of Disease Control and Prevention

CHD: chronic heart disease

CSFII: Continuing Survey of Food Intakes by Individuals

CVD: cardiovascular disease

DBP: diastolic blood pressure

DM: diabetes mellitus

DMC: Detroit Medical Center

FEQ: food environment questionnaire

FPQ: food picture questionnaire

HIPPA: Health Insurance Portability and Accountability Act

HOMA-IR: homeostasis model assessment for insulin resistance

IDF: International Diabetes Federation

IRB: institutional review board

LDL: low density lipoprotein

MetS: metabolic syndrome

NHLBI: National Heart, Lung, and Blood Institute

NHANES: National Health and Nutrition Examination Survey non HDL-C: non HDL cholesterol

oAAA: obese African American adolescent

PTH: parathyroid hormone

RA: research assistant

SBP systolic blood pressure

T2DM: type 2 diabetes mellitus

TC: total cholesterol

TG: triglyceride

WC: waist circumference

WHR: waist and hip ratio

CHAPTER 1

INTRIDUCTION

Overweight and obesity have become a significant public health problem in the United States and on a global scale. The overweight and obesity prevalence has increased from 61.9% to 65.8% for adult females and 67.2% to 71.3% for adult males from 1999-2012 (1-3). Even though there have been no significant changes from 2003 to 2012, the prevalence remains high. Compared to the general adult population, which has an obesity prevalence of 34.9%, the obesity prevalence for non-Hispanic blacks increased to 47.8% in 2011-2012 where it remains the highest rate among all ethnic populations. Furthermore, non-Hispanic black females have the highest obesity prevalence of 56.6% among all adults (4).

Body mass index (BMI) is the most widely used tool in the clinical diagnosis of obesity and body fat mass. In contrast to adult BMI, pediatric medical professionals use BMI percentiles based on age and gender specific standards (5). The BMI in the 5^{th} to 85^{th} percentile is considered healthy; a score between the 85^{th} and 95^{th} percentile is considered overweight; and a score over the 95^{th} percentile is considered obese (6).

Pediatric obesity has dramatically increased in the past decades and has become a major health issue not only in the United State but also worldwide. Adolescents with overweight and obese diagnoses were 10.5% between 1988 and 1994 and increased to 15.5% between 1999 and 2000 (7); this further increased to 33.6% and 18.4% for overweight and obese respectively in the US adolescent population between 2009 and 2010 (8). Health care costs related to childhood obesity have increased from $125.9 million to $237.6 million between 2001 and 2005 (9). Since obese adolescents are more likely to become obese adults (10), pediatric obesity prevention has become a top priority in health care. The most recent National Health and Nutrition Examination Survey (NHANES) data show that 23.7% of the African American adolescent (AAA) population was obese between 2009 and 2010 (8). This number was the second highest when compared to Hispanic American adolescents with an obesity prevalence of 23.9%, in contrast to the overall adolescent population which was 18.4%.

Obesity, T2DM and CVD

Obesity is related to many chronic diseases such as coronary heart disease, cardiovascular disease (CVD), type 2 diabetes mellitus (T2 DM), hypertension, gallbladder disease, stroke and certain types of cancers such as colon, endometrial and breast for postmenopausal women in adults as well as poor health outcomes (11-14). Based on the 2012 report from the Center of Disease Control and Prevention (CDC), heart related disease is the number one cause of death after adjusting for age factor with a death rate of 191.4/ per 100,000 population while diabetes mellitus (DM) is in 7th place with a death rate of 23.5/per 100,000 population (15). With the high obesity prevalence in the US, the obesity population with increased risk for T2DM and CVD are also suffering from a high risk of mortality from these diseases. Therefore, studies on CVD and T2DM risks in the obese population and how to decrease the mortality caused by these two diseases are important.

The high prevalence of pediatric obesity has increased the vulnerability of chronic diseases in a younger age group. The onsets of T2DM, CVD, and hypertension have started at a younger age. Evidence showed that T2DM is now the most common type of DM in school children (16) and CVD is strongly associated with obesity even in adolescence (17). Since studies have shown that AAA have an elevated obesity prevalence (41.2%) (8), this population is at a high risk for developing chronic diseases that used to occur only in adulthood. Therefore, developing age-specific early detection and prevention strategies for these diseases is vitally important.

Metabolic syndrome (MetS)

Obesity affects factors associated with CVD (18) but the sole use of BMI cannot track the development of T2DM and CVD. Thus, researchers focused on cardiometabolic risk factors when studying these relationships. Individuals with metabolic syndrome (MetS) have a relative risk of 2.88, 2.54, and 6.92 of developing new CVD, chronic heart disease (CHD), and T2DM respectively over an 8 year period (19). As a precursor of T2DM, CVD and CHD, MetS has become a new focus for research in order to understand the development and prevention of these chronic diseases.

MetS is defined as a constellation of cardiometabolic risk factors associated with increased risk of T2DM and CVD mortality rate (20, 21). These risk factors include high waist circumference, high levels of fasting blood triglycerides, glucose and blood pressure, as well as low serum HDL levels. Having three of these five risk factors is considered a diagnosis of MetS. Even though the pathogenesis of MetS is not clear, obesity (especially abdominal or central adiposity) and insulin resistance appear to play important roles (22). Therefore, examination of the prevalence and etiology of MetS could help better target the need for an efficacious prevention of CVD and T2 DM. Moreover, understanding the mechanisms behind MetS could point in the right direction for reducing the mortality rate caused by CVD and T2 DM.

Adult MetS criteria with some modifications have been applied to the pediatric population for the early phases of MetS-related study in this population (23). However, these criteria may not suit the pediatric population due to the different cutoff points for BMI, waist circumference, lipids and blood pressure of children. Therefore, different definitions for pediatric MetS have been developed. Cook et al. proposed the first MetS definitions for adolescents in 2003 and reported a 4.2% prevalence of MetS (23). More studies have been focusing on MetS in the pediatric population afterward, but different cutoff points and standards have been used. The most frequently used definitions were suggested by Weiss et al (24), Cook et al (23), Ford et al (25), and Cruz et al (26). However, by using different standards for MetS it is difficult to compare different study results. Lee et al (27) compared 4 different MetS definitions reported previously in literature to assess the prevalence of MetS among 251 children, with ages ranging from 8 to 19 years. The author pointed out a wide range of MetS prevalence from 13.4% to 25.1% when using different definitions in the same population. Despite this variance, MetS prevalence continues to be higher in obese children and adolescents compared to normal weight children and adolescents. Therefore, in 2007 (28) the International Diabetes Federation (IDF) unified the criteria for pediatric MetS by taking into consideration of all the standards used. For adolescents aged 10-16 years old, the definition for MetS is based on the waist circumference above the 90th percentile and any two more risk factors out of the other four factors such as high blood pressure, hyperlipidemia, hyperglycemia, and low HDL level (Table 1). The IDF criteria for pediatric MetS have been applied to Middle Eastern, North African and Brazilian adolescents (29) (30) but not yet used for the AAA population.

In a 15 year follow up study, the Bogalusa Heart Study observed that children who have fewer metabolic syndrome factors are favorably associated with lower levels of cardiovascular risk in adulthood (31). Moreover, Morrison et al. reported in a longitudinal study that children, ages 5 to 19 years old, with MetS and a family history of diabetes could be at increased risk for developing T2 DM and MetS in adulthood after 25 to 30 years (32). The same study by Morrison et al later reported that childhood MetS is a predictor for adult MetS after 25 years (33). Therefore, identifying MetS in early childhood may provide an early opportunity to prevent further development of MetS in adulthood.

There are conflicting reports about the prevalence of obesity, CVD, and MetS in the African American (AA) population. As mentioned previously, AAs have the highest obesity prevalence compared to other ethnic groups. They

Table 1: MetS definition: International Diabetes Federation criteria (28)

Age 10–16 years:				
Obesity (WC) ≥90th percentile Plus 2 of the following:	Triglycerides: ≥ 150mg/dl	HDL-C: < 40mg/dl	Blood pressure: SBP ≥130 mm Hg DBP ≥85 mm Hg	Glucose: ≥ 100mg/dl or known diabetes
Age >16 years: use IDF adult criteria				
WC: ≥94 cm (men) ≥80 cm (women) Plus 2 of the following:	Triglycerides: ≥ 150mg/dl	HDL-C: <40mg/dl (Male) < 50mg/dl (Female) or treatment	Blood pressure: SBP ≥130 mm Hg DBP ≥85 mm Hg or previously diagnosed hypertension	Impaired fasting glucose or type 2 diabetes

also have a high CVD rate of 7.7 per 1000 persons and the mortality hazard ratios of CVD mortality is 3.93 which were both higher than non-Hispanic white and Hispanic populations (34). However, AAs have the lowest prevalence of MetS at 21.6% when compared to White and Hispanic populations with prevalence of 23.8% and 31.9% respectively (35). Similar results were found in adolescent populations. According to the 2001-2006 NHANES, by using the MetS criteria based on Ford et al's study (36), 8.6% of adolescents have MetS. White and Hispanic adolescents had a MetS prevalence of 8.9% and 11.2% respectively, while African American adolescents have a 4% prevalence of MetS, which is lower than the average, and the lowest among all ethnic groups – the reason for this dis-concordance is not yet clear. Therefore, further investigation into the high prevalence of obesity and CVD while maintaining low MetS rates in the AAA population is warranted.

Other metabolic risk factors

In the adult population, the relationship between MetS, obesity, and T2DM is clearly characterized while in the adolescent population the research is still in progress. Despite the metabolic risk factors used to define MetS, there are several other risk factors that are highly related to obesity which could have made an impact on the AAA population. These include other serum lipids, insulin, leptin, vitamin D and calcium levels.

Insulin and leptin are hormones in the body involved in energy metabolism, and are highly associated with obesity. Insulin is a hormone secreted by the pancreas that, together with glucagon, maintains glucose homeostasis, thus the malfunction of insulin secretion or sensitivity will cause metabolic defects (37). Insulin resistance is strongly related to obesity and T2DM. Defects on the hepatic insulin receptor and post-binding in peripheral tissues such as adipose tissue are the primary cause of insulin resistance (38, 39). Higher levels of obesity lead to a higher levels of insulin resistance due to the higher adipose tissue content in the body (40).

Leptin is a hormone secreted by adipocytes, which regulates energy balance, neuroendocrine functions, sexual maturation, glucose homeostasis and appetite (41-44). By circulating through the hypothalamus, leptin reduces food intake and increases energy expenditure. Moreover, leptin improves insulin sensitivity in muscles and in the liver (44) which has beneficial effects in preventing T2DM and obesity. Obese individuals, due to their higher amount of adipose tissue, have a higher concentration of leptin in their blood compared to people at a healthy weight, which implied leptin resistance state in these obese individuals (45, 46). The mechanism of leptin resistance is not clear, but according to Caro et al (46), the lowered capacity of the leptin transporters to transport leptin to the brain could be one of the causes. The leptin level in the obese subjects was 40 ng/ml based on the Caro study. Even though leptin plays an important role in obesity, there are limited studies on the leptin level and MetS. Esteghamati et al conducted a study to explore the association of leptin levels with MetS in obese and non-obese adults (47). They discovered that leptin was highly associated with MetS regardless of weight status, and it has an independent role in the development of MetS. However, similar studies have not been conducted in adolescent populations.

Calcium intake, vitamin D deficiency and obesity

Calcium intake and vitamin D deficiency are also associated with obesity. The Institute of Medicine defines Vitamin D deficiency as serum 25-hydroxy vitamin D (25-D) levels less than 20 ng/mL (50 nmol/L) (48). Research has reported that intracellular calcium plays an important role in fat deposition in mouse models (49). Research on human subjects has shown that calcium increases body fat oxidation after a single or multiple meals and promotes a modest energy loss through increased fecal fat content (50). One study on obese African American adults showed that after controlling calorie intake, the group that consumed a diet rich in calcium had lower body fat content (51).

In addition to low calcium levels, previous research has found low vitamin D levels in obese adults – especially African Americans (52). Similar results have been reported in children 6-18 years old and showed that severely obese children had a higher prevalence of vitamin D deficiency (49%) compared to obese and overweight children (34% and 29%) and only 21% of adolescents with a healthy weight were vitamin D deficient (53). African Americans have a higher prevalence of vitamin D deficiency compared to White and Latino populations in the United States, 68%, 12%, and 38% respectively (53). Consequently, vitamin D deficiency might be a risk factor for obesity. Another study showed that calcium and vitamin D interact together to increase body fat oxidation after meals, and that calcium promotes modest energy loss (54). In other words, insufficient serum calcium and vitamin D may prevent fat loss and may be one of the causes of obesity. Moreover, Maki et al revealed a reverse association between vitamin D intake and MetS prevalence (55) for adult populations. Most research had been conducted on 25-D, but little has studied the relationship between 1,25-dihydroxyvitamin D (1,25 D3), the active form of vitamin D, and MetS in the adolescent population. One of the aims of this study included examination of insulin, leptin, calcium and 1,25 D3 levels in the blood and explore the possible relationships between these parameters and MetS in the obese African American adolescent (oAAA) population.

Diet and Food environment

Regardless of the genetic, environmental, and behavioral factors, an unhealthy diet also contributes to the development of pediatric obesity. A positive energy balance from excessive consumption of calories from food and beverages will cause weight gain (56). Food consumption and dietary patterns could be another important element to the causes of MetS (57). Dietary patterns such as total energy intake, cholesterol, total fat, protein, fiber, sodium, potassium, vitamin D, and calcium consumption could be key factors that influence MetS development in the AAA population.

Lacking knowledge about healthy eating behaviors and healthy food choices could determine one's food consumption, which in turn may affect the growth and development (58). Moreover, food preference can also be associated with food consumption and further impact body weight. Research has been conducted on preference and consumption of fatty snack foods (59). This research showed that children with preferences for fatty snacks have higher consumption of dietary fat and, fatty snack intake was positively correlated with BMI. Thus, knowledge about nutrition and eating behavior/patterns may be associated with the prevalence of MetS via elevated fat intake in the AAA population.

Modern lifestyles have changed eating patterns in US families. Based on the 1994-1998 report by the Continuing Survey of Food Intakes by Individuals (CSFII), 50.3% of adolescents age 10-19 years reported eating at fast food restaurants during a 5-10 day period (60). This study demonstrated that total calorie intake was significantly higher in these adolescents on the days they consumed fast food in comparison to days without fast food consumption. Adolescents who consumed fast food reported significantly higher average daily calorie intake than those who did not consume fast food (60). This study indicated African Americans had the highest fast food consumption rate of 45.8%, followed by White (42%) and Hispanic (40.5%) populations. The CDC's National Center for Health Statistics report also showed that in young African Americans adults, the frequency of fast food consumption was high, and a high percentage of calorie intake was from fast food (61). Moreover, obese adults regardless of age consume a larger percentage of calories from fast food when compared to overweight and normal weight adults. Fast food restaurants are the establishments where children consume more than 1/3 of their calories from solid fat and added sugar (62). Among these children, 46% were adolescents. No research has explored the relationship of fast food consumption with MetS in the AAA population, and it deserves further investigation.

Hypothesis

As mentioned previously, there is a paradox in the prevalence of obesity in AAA and the prevalence of MetS. AAA have the lowest MetS prevalence among all ethnic groups (63) but they have a higher prevalence of obesity. Other approaches have been used in order to build a model or profile that best defines MetS in this population. Confirmatory factor analysis, a model that tests whether the measures are consistent with the constructs that were tested, has been used in adolescents to analyze the best fit model for MetS and account for the ethnic difference at the same time (64). Another study also used confirmatory factor analysis in AAA to fit the best profiles on MetS and reported the best fitting model contains waist circumference, fasting insulin, HDL, and systolic blood pressure. The last aim of this study is to analyze all the risk factors in the oAAA to identify the best fitting model for this population(65).

The hypothesis of this study is that oAAA will have a high rate of MetS by using the new IDF standard. In addition, by combining more physiological data and control for environmental elements an ethnic specific MetS profile for this population could be developed. The specific aims of this study were:

1: To verify that MetS rate is elevated in oAAA who reside in a Midwest metropolitan area as defined by the IDF standard of MetS for adolescents.

Basic anthropometric data and blood lipid profiles were collected and examined to determine MetS rate in oAAA. The overweight/obese population would have a higher rate of MetS compare to the general population. The IDF standard is attached in Table 1 (28).

2: To examine serum calcium,1,25 D3, insulin and leptin levels in oAAA with and without MetS

Studies found that lower levels of serum calcium and vitamin D are associated with higher body weight. Insulin and leptin are hormones related to adipose tissue metabolism and are well known to be associated with obesity. Fasting blood samples drawn from the participants were collected, and levels of calcium, 1,25 D3, insulin and leptin levels were determined.

3: To develop a Metabolic Syndrome profile in this oAAA population.

African American Adolescents have relatively high obesity prevalence. However, they have the lowest prevalence of MetS among all the ethnic groups. This study aimed to improve our understanding of the relationship between MetS, serum calcium, vitamin D, insulin levels, leptin levels, and dietary patterns in participants with and without MetS.

CHAPTER 2

METHODS

Recruitment

This study collected data from the FIT Family project at Wayne State University. The FIT family project was a program supported by a grant: "Interventionist Procedures for Adherence to Weight Loss Recommendations in Black Adolescents-Wayne State University" from the National Institutes of Health. The study collaborated with several Detroit Medical Center (DMC) clinics for recruitment. Patients in these clinics who fit the eligibility criteria were referred by the staff or physicians to the program. Since the aim of this study was to investigate MetS in obese African American adolescents, criteria for recruitment were as follows: African Americans aged 12 years to 16 years 11months at the time of data collection; families living within 30 miles from the FIT family project center; and participants that were deemed obese (BMI percentile greater than 95th percentile based on CDC's growth chart) (66). After receiving the information, research assistants (RA) of the FIT Family project then contacted caregivers of these adolescents by phone to introduce the project and screen these families again for any eligibility issues. If they are interested in participating then a data collection appointment was scheduled. Recruitment was done over a three year period in four different cohorts starting in 2011 and ending in 2013. The original study design aimed for 200 participants but due to time constraints, only 186 participants were recruited.

Participants

Adolescents who did not complete all the data collections were excluded from the study. Reasons for incomplete data collections included: refusal of blood draws due to aichmophobia (fear of needles), unobtained results due to large body sizes being incompatible with the blood pressure machine, and adolescents who didn't answer the door/missed the deadline for home blood draws. By excluding subjects with incomplete data collections, the total number of oAAA who have completed data for MetS were 168 (down from 186).

After combining both results from the research lab and the DMC clinic lab (methods described below), outliers were detected and deleted. Z scores were calculated for all the variables using SPSS software (see below). Z scores more than 3.0 and less than - 3.0 were considered outliers since they were located over 3 standard deviations away from the mean. Two subjects with a body weight over 400lb were detected as outliers for waist circumference, BMI, and blood pressure. Two outliers were detected for blood pressure, three subjects had glucose levels more than 190 mg/dl, and one of them also had an insulin level of more than 290 µU/ml, which made them outliers. One subject with TG levels more than 350mg/dl, 2 subjects with vitamin D levels more than 105pg/ml, and 3 subjects with insulin levels more than 250ng/ml were all identified as outliers. One subject with HDL levels of 62 mg/dl and another one with leptin levels of 147ng/ml were both considered outliers. Finally, 2 subjects were excluded due to incomplete data from the DMC clinic. In conclusion, a total of 17 subjects were removed as outliers. This left 151 viable samples for further data analysis. The mean age of 151 oAAA was 13.8 ± 1.4 years, 66.7% girls, BMI was 37.8 ± 7.5kg/m^2, and BMI percentile was 98.5±4.4.

Metabolic Syndrome Defined

The MetS definition used in this study is taken from the IDF criteria that includes high waist circumference plus any two of the other four risk factors: low HDL, hypertension, hyperglycemia and hypertriglyceridemia. For adolescents age 10 to15, high waist circumference was defined as equal or over the 90th percentile that was age, ethnicity and gender specific from 1999-2008 NHANES data (67). HDL concentration of less than 40 mg/dl was considered low HDL regardless of gender, and glucose concentration more than or equal to 100mg/dl was considered as hyperglycemia. Systolic blood pressure of more than or equal to 130mmHg or diastolic blood pressure more than or equal to 85mmHg was considered another risk factor. Triglyceride (TG) concentration equal to or more than 150mg/dl were considered as a MetS risk factor. Since the IDF pediatric criteria for MetS considered 16 years old an adult and used the adult criteria, cutoff points for HDL and waist circumferences were defined differently while others remained the same. For ages 16 and older, high waist circumferences was considered ≥90cm for males and ≥80cm for females and low HDL was defined as <40mg/dl for males and <50mg/dl for females.

Data Collection

Data collection was divided into two separate visits. The first visit was a 2.5 hour long data collection which included the consent form, paper and pencil questionnaires, and anthropometric measurements. Heights and weights were first measured to calculate BMI percentile to confirm the eligibility before the data collection took place. BMI percentile was calculated based on the CDC's online calculator (6). The second visit was for a blood draw by a phlebotomist. The participating family received a $50 incentive for completing each data collection.

The first data collection appointment was scheduled at the participants' residence. The research assistant (RA) started with the paper and pencil consent form. Both caregiver and adolescent signed a consent form for the study that was approved by the institutional review board (IRB) of Wayne State University. A Health Insurance Portability and Accountability Act (HIPAA) Authorization form is also signed by the caregivers. The HIPAA Authorization form is used to verify that the legal guardian has given their consent that data relevant to their child's participation in the research project may be extracted from their child's medical record maintained by Children's Hospital of Michigan. The HIPAA authorization form explains what information will be collected and for what purpose, who will have access to the information, and how to change their minds about allowing access to medical record information. A copy of the HIPAA authorization form was provided to the caregiver for record keeping.

Adolescents answered a set of paper and pencil questionnaires regarding their health, beliefs, exercise, food environment, and eating habits. Only questions about weekly food intake, nutrition knowledge, food preferences, and fast food consumption were included in this study. The anthropometric measurements were also collected.

Anthropometric Measurements

Height: Height was measured by a 213 mobile stadiometer from SECA (Hanover, MD).

Weight: Body weight was measured by a portable digital 869 scale with a weight capacity of 550 lbs from SECA. Weights were measured twice on different days of the week and the average weight was used in the study.

Extreme Obesity: To define extreme obesity, Flegal and colleagues suggested that 120% of the smoothed 95th percentile, instead of the 99th percentile on the growth chart, is a better fit for categorizing extreme obesity (68). On the same study, the authors applied this new cutoff point to the 1999-2004 NHANES data and discovered a higher overall prevalence of extremely high BMI in both genders and across all the age groups, especially for adolescent girls (age 12-19). The prevalence rate was almost double that of other groups (5.4% compare with 2.2%). Our study calculated both standards to compare the extreme obesity rate in oAAA population.

Waist and Hip Circumference: Waist and hip circumferences were measured by a SECA 201 Measuring Tape, and they were calculated waist and hip ratio (WHR) was defined as waist circumference divided by hip circumference. According to the World Health Organization, WHR is an anthropometric indicator of central obesity. The cutoff point is WHR > 0.9 for men and WHR > 0.85 for women (69), but there is not a clearly defined metric for children (70).

Blood Pressure: Systolic and diastolic blood pressures were measured three times and the final results were the average of the three measurements. It was measured by using an automatic blood pressure monitor (model HEM-711) from Omron Healthcare Inc. (Bannockburn, Illinois) and Life Source blood pressure monitor from A&D Engineering, Inc. (San Jose, CA). The Omron machine provided normal cuffs for the measurement and the Life Source blood pressure monitor was used when arms of the participants exceeded the size of the Omron cuffs (16.5-23.6 inches). The results from both machine was validated.

Body Fat Percentage: Body fat was measured using the portable Quantum II (Q324311) bioimpedance analysis (BIA) machine from RJL Systems (Clinton Township, MI). The machine uses bioelectrical impedance as an indirect measure for body composition. The measurements and basic anthropometric data for each participant were entered into the RJL computer software to calculate body fat percentage. Study has shown that bioelectrical impedance analysis is a reliable method to measure body fat and has been conducted in adolescents of different ethnic groups (71).

Measurement Description

First Visit:

Fast Food Use (Appendix A): Fast foods usually contain higher fat and sugar content. This questionnaire was created by the research group aimed to understand the frequency of fast food consumption in oAAA. The questions asked how many days these adolescents consumed food from a fast food restaurant within the past week and if that was more, less, or the same as most weeks.

Block Food Frequency Questionnaire (BFFQ) (Appendix B): Dietary records of oAAA were obtained by the BFFQ. This is a scantron form questionnaire that has 77 of the most commonly consumed food items based on the 1999-2002 NHANES dietary recall data (72). The adolescents were asked to record whether or not they have eaten a specific food over the past 7 days, the amount of that food eaten, as well as the frequency. The scantrons were sent back to NutritionQuest to calculate total dietary calories, carbohydrates, protein, total fat, cholesterol, monounsaturated fat, poly unsaturated fat, saturated fat, calcium, vitamin D, fiber and sugar based on their answers (www.nutritionquest.com Berkley, CA).

Food Picture Questionnaire (FPQ) (Appendix C) (73): This FPQ was administered by the RA to the adolescents. There are 12 set of pictures and each picture contains a pair of foods, one considered healthy and the other less healthy. These foods included: hamburger and salmon; vegetable with butter, vegetable only; popcorns and donuts; fried eggs and bacon; pretzel and potato chips; fried chicken and grilled chicken; cheetos and cereal; fresh fruit and fruit candy; turkey sandwich and hot dog; milk and soda; baked potato and French fries; and apples and cookies. The adolescents were then asked questions regarding their preference, knowledge, and frequency of consumption about each food pairing and the RA recorded the responses on the data collection form.

Food Environment Questionnaire (FEQ) (Appendix D): This questionnaire was designed by the researchers in the study to evaluate food availability in the household. It was answered by the caregivers of the adolescents. Since all these adolescents were living with their caregivers, the food that was consumed by these adolescents were highly dependent on what caregivers purchased. This questionnaire provided information of what sorts of food were available in the home environment. It is part of the home environment report which contains food, as well as indoor and outdoor activity environments. Only food environment data were reported in the current study. There were 22 items in the food environment section which contained options from grains, fruits, vegetables, meats to beverages. Out of the 22 options 11 of them are healthy choices while the others are less healthy. Caregivers were to answer if these food items were at home for immediate reach by their teens.

Second Visit:

Blood Parameter Measurements

Within a 2 week window of the completion of the first research visit the project phlebotomist then made an appointment for a blood draw. Participants were asked to fast at least 8 hours before the blood draw appointment. The appointments were usually on weekday mornings before the participant went to school or on weekends. A total of 15ml of blood was drawn from the participant via a vein in the arm and immediately transferred to a vacutainer containing EDTA. The specimens were transported to the lab on ice in less than 2 hours for centrifuge. The plasma was then transferred to small storage tubes and kept in a freezer for future analyses. However, if the participants refused a home blood draw or the phlebotomist wasn't able to draw blood from the participants over 2 attempts of home blood draw, they were referred to DMC University laboratories to have their blood drawn in the clinic. In order to combine the blood assay results with the anthropometric data and questionnaire, a 2 week window was established for the blood draw after the first data collection.

After the blood samples were collected, plasma samples were used to measure blood lipid profile, calcium, insulin, and leptin concentrations. Total cholesterol (TC) and HDL cholesterol, TG, glucose, and calcium concentration were measured through a plate reader using assay kits purchased from Point Scientific (Canton, MI). Insulin concentration was measured by a radioimmunoassay using kit purchased from MP Medicals (Solon, OH). Leptin concentration was also measured by a radioimmunoassay using kits ordered from Millipore (Billerica, MA). 1,25 D3 assay was an ELISA assay and the kit was ordered from Christal Chemical Company (Wakefield, MA).

Not all of the results were obtained by lab assays, some were calculated. Non HDL Cholesterol (non HDL-C) concentration was calculated as TC (mg/dl) – HDL (mg/dl). Low density lipoprotein (LDL) concentration was calculated based on Friedewald equation LDL= TC(mg/dl)-HDL (mg/dl)-TG(mg/dl)/5 (74). Insulin resistance was calculated by the homeostasis model assessment for insulin resistance (HOMA-IR) developed by Matthews et al in 1985 (75). It's calculated by using fasting insulin and glucose level (insulin (μU/ml) ×glucose (mg/dl)/405) assuming that normal young individuals have an insulin resistance of 1.

Statistics

All the data collected was analyzed by IBM SPSS software version 22 (IBM Corp, Armonk, NY). The rate and percentage of each individual risk factor of MetS and MetS prevalence were computed. Basic description and frequency data were conducted for all the anthropometric data, blood assay results and MetS risk factors. A simple one-sample t test was used for comparing blood lipids with the National Lung, Heart and Blood Institute standard (76). Blood insulin, leptin, calcium and vitamin D concentrations were compared with the range and the mean values of the national population. Pearson correlations were conducted to test the relationship among all these factors. These analyses were also conducted for different age and gender.

Results from the Block food questionnaire had a wide range for calorie intakes – from 150 kcals to more than 5000 kcals. Based on the dietary guideline of the study, total calorie intakes of 500 kcals and less were deleted. After running the statistics for outliers, it was determined that total calorie intake of more than 3500 kcals were 3 standard deviations above the mean energy intakes and were also excluded from analysis. A total of 18 subjects were excluded for further analysis of dietary data. The data was also checked for skews and normality. Log transformations were conducted to normalize variables which were not normally distributed.

The Nutrition Picture Questionnaire and FEQ were both calculated before analysis. Healthy options were scored a 1 and unhealthy options were scored a 0. The sum of these scores represented a final score for each participant. The highest score for the nutrition picture questionnaire was 12, whereas the FEQ was 22. The final scores were then divided by the question items answered to give a correct percentage to adjust for the missing questions that were not answered.

The final results were presented as percentage for further calculation. Significance level was set at $p<0.05$.

Independent t tests were conducted between oAAA with MetS and without MetS to investigate the difference in all the dependent variables. Since the dependent variable was dichotomous (with MetS and without MetS), a binary logistic regression was conducted to estimate the contribution of each risk factors. The dependent variable was whether or not oAAA have MetS, and the independent variables were the continuous data of the five metabolic risk factors. The exp(β) represents the odds that each risk factors will increase MetS.

In order to predict MetS by all the other variables that's not defined as the risk factor for MetS, binary logistic regressions were performed. The dependent variable was whether or not oAAA have MetS. The independent variable included the anthropometric data, lipids profiles, insulin resistance, calcium, 1,25 D3, FEQ, and FPQ. Gender and age differences were also tested separately.

Since there were many independent variables, factor analysis was performed using principal components analysis to categorize highly intercorrelated variables into few "clusters" (77). The clusters can be as many as the independent variables and the minimum clusters were identified by eigenvalues =1 by the default setting of SPSS. Varimax was selected as the rotation method to recalculate the interpretable factor loading for the variable in the clusters and each of the clusters were uncorrelated with each other. Factor loading of the variables in each cluster were associated either positively or negatively with the cluster. The cutoff point for the factor loadings was 0.30 and was based on the research of cardiovascular risk factors clustering in Bogalusa study (77). The regression factor scores of these clusters conducted by the principal components analysis were further used in logistic regression to test if these clusters could predict MetS.

CHAPTER 3

RESULT

Specific Aim 1: To understand metabolic syndrome (MetS) risk in oAAA who reside in a Midwest metropolitan area by using the IDF standard of MetS for adolescents.

General Anthropometric Data

A general univeriate model for age and gender for BMI (Fig. 1) and for BMI percentile (Fig. 2) was conducted for oAAA. No age and gender interaction were found for BMI but age affected the BMI distribution ($F=2.9$, $p<0.05$). BMI started to increase significantly for both boys and girls after age of 14. There was a divergence in BMI percentile: an increase for boys but a decrease for girls after age 14. Thus, 14 years old appeared to be a good age cutoff point for analysis since from 12 to 14 years there was little change in BMI. The results also showed a significant change occurred between genders after 14 years of age. Therefore, the age group was divided into 2 categories: 12-14 years (Young) and 15-16 years (Older) for further analysis.

This group of oAAA had a high extreme obesity (BMI greater than 99^{th} percentile) rate. Based on CDC's growth charts, 54% of the oAAA were extreme obese. Moreover, 74% of oAAA (82.7% of boys and 69.7% of girls) were extreme obese by using the 120% of the 95^{th} percentile cutoff point. The Young group had a 74.2% rate while the Older group also had 74%.

Blood lipid, glucose, insulin, leptin, and calcium levels of majority of the oAAA were measured in the research lab. Fourteen oAAA who were all in

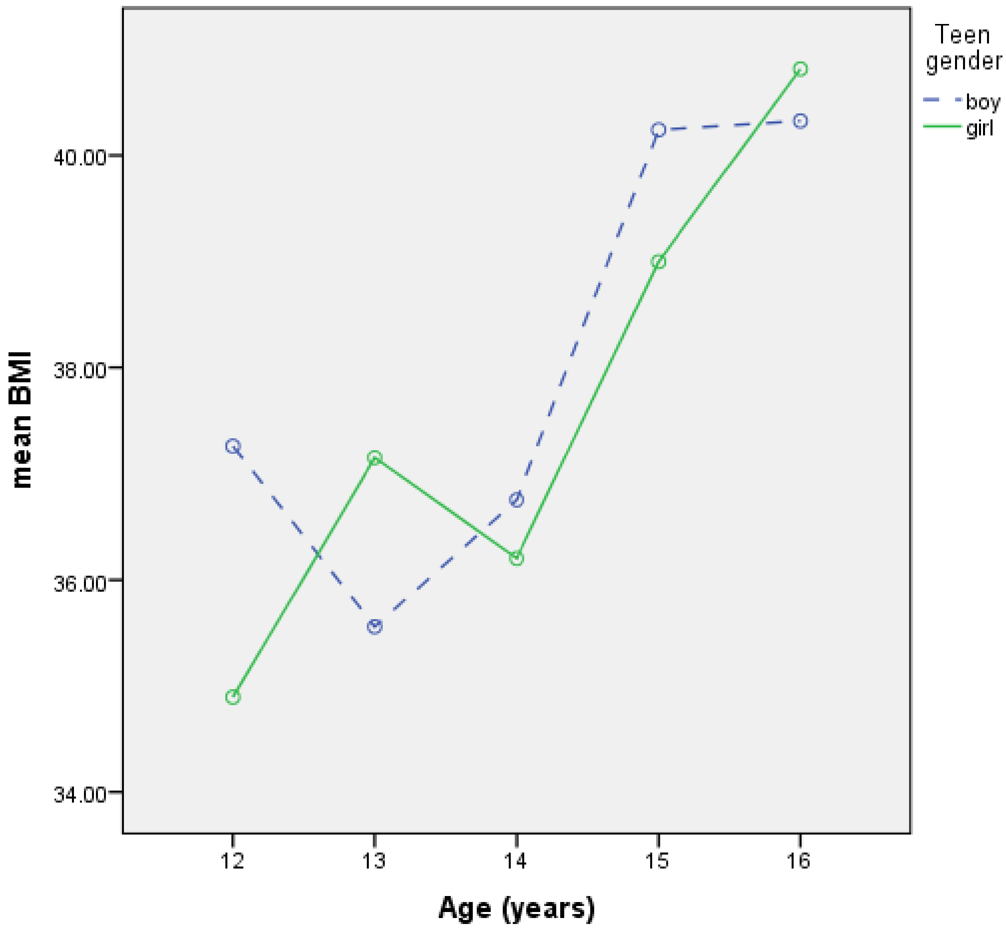


Figure 1: Univeriate model for age and BMI separated by gender.

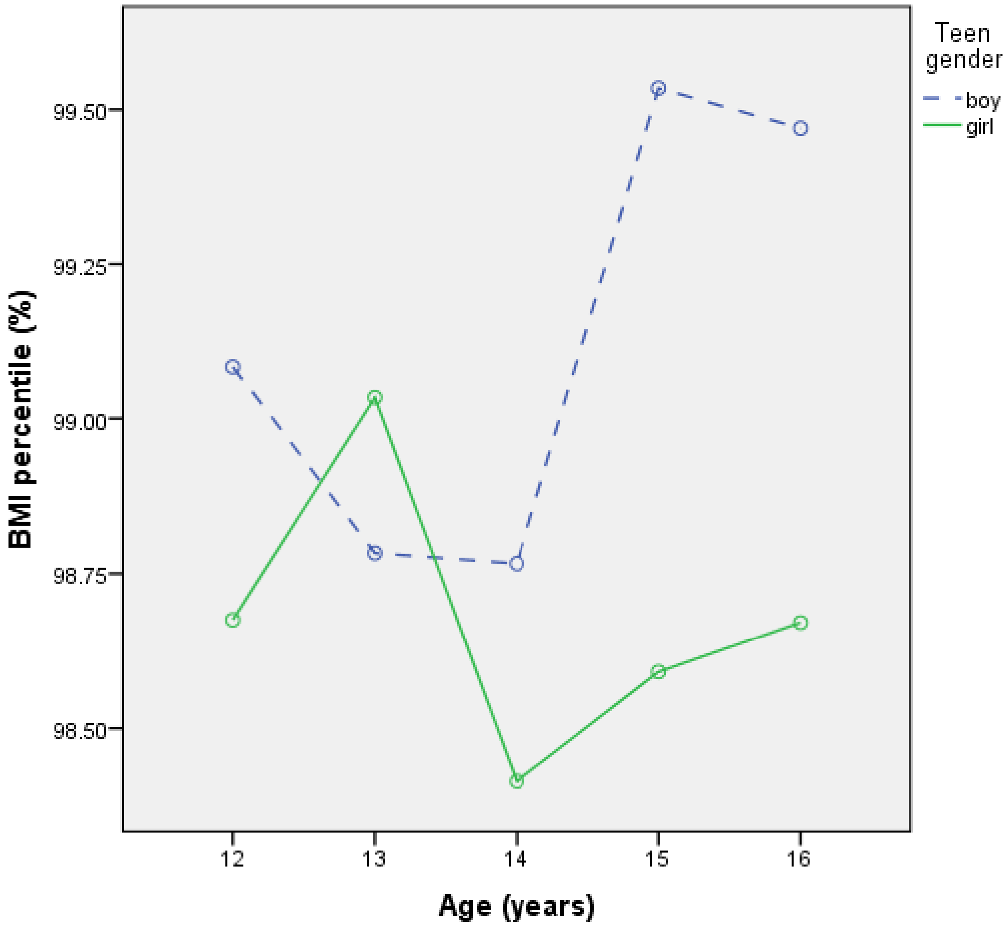


Figure 2: Univeriate model for age and BMI percentile separated by gender.

Table 2: Blood assay result from lab and DMC clinic

	Research Lab (n=154)	DMC clinic (n=14)	p
Glucose (mg/dl)	105.4 ± 23.9	97.2 ± 58.5	0.303
TG (mg/dl)	92.2 ± 40.8	105.7 ± 77.5	0.282
HDL (mg/dl)	30.9 ± 9.2	44.7 ± 9.8	<0.01
TC (mg/dl)	148.1 ± 39.9	175.1 ± 35.0	<0.05
Insulin (µU/ml)	75.5 ± 55.4	63.3 ± 80.8	0.464
Leptin(ng/ml)	62.9 ± 24.0	48.8 ± 34.3	0.054
Calcium (mg/dl)	9.2 ± 0.8	9.4 ± 0.3	0.610

DMC: Detroit Medical Center; TG: triglyceride; TC: total cholesterol the Young group chose to go to DMC clinic for the blood test (Table 2). Independent t tests were performed and no significant differences were observed in TG, calcium, insulin, leptin, and glucose levels between the samples measured in the lab and those measured by DMC clinic. However, both HDL and TC level were higher for samples measured in DMC (44.7 ± 9.8 mg/dl vs 30.9 ± 9.2 mg/dl, $p<0.01$; 175.1 ± 35.0mg/dl vs 148.1 ± 39.9mg/dl, $p <0.05$ respectively). Since the sample size was small for samples measured in DMC clinic they were consider to have less power. Therefore, results from both clinic and research lab were combined for further analysis. Basic descriptive data were shown in Table 3.

MetS rate by using IDF standard

Percentage of oAAA who met each of the MetS factors, as well as more than one factor, are shown in Table 4. High waist circumference was observed in 98.7% of the participants, the highest percentage, followed by low HDL (82.8%), and hyperglycemia (54.3%). Hypertension which including both systolic (SBP) and diastolic blood pressure (DBP) and hypertriglyceridemia were both lower than 25%. Close to 62% of the oAAA population had MetS as defined by having any three or more risk factors. For each additional unit increase in glucose and SBP, the odds of having MetS was increased by 12% and 9% respectively (Table 5), and for an unit increase of HDL level the odds of having MetS was lowered by 15%. No significant effects were found in any changes in DBP, TG, and waist circumference. The IDF criteria of MetS was high waist circumference and plus any two of the other four risk factors. Table 6 showed all possible MetS rates by permutations of any three of the five risk factors. There were a wide range of

Table 3: General characteristics of the study sample

N=151			
Age	14.27 ± 1.4	TG (mg/dl)	90.7 ± 39.9
Gender	65.6% girls	HDL (mg/dl)	31.7 ± 9.3
Weight (lb)	224.9 ± 47.3	TC (mg/dl)	150.4 ± 39.3
Height (inches)	64.9 ± 2.7	LDL (mg/dl)	100.6 ± 37.7
Percentage body fat (%)	47.8 ± 7.2	Glucose (mg/dl)	103.2 ± 21.8
BMI	37.4 ± 7.2	Non HDL-C (mg/dl)	118.7 ± 39.1
BMI percentile	98.8 ± 1.1	Insulin (µU/ml)	66.9 ± 39.1
BMI z score	2.4 ± 0.3	Leptin (ng/ml)	61.6 ± 24.1
Waist (inches)	43.5 ± 6.0	HOMA-IR	17.6 ± 12.8
Hip (inches)	48.0 ± 6.3	1,25 D3 (pg/ml)*	46.2 ± 18.0
Waist to hip ratio	0.91 ± 0.07	Calcium (mg/dl)	9.2 ± 0.8
Systolic blood pressure (mmHg)	121.3 ± 9.1		
Diastolic blood pressure (mmHg)	73.8 ± 8.6		

*n= 142

1, 25 D3: 1,25-dihydroxyvitamin D; HOMA-IR, homeostatic model assessment of insulin resistance; TC, total cholesterol; TG, triglyceride

Table 4: Cardiovascular risk factor, metabolic syndrome rate and numbers of risk factors by IDF standard in oAAA population

	N=151
High Waist circumference	98.7%
Hypertension	24.5%
Systolic blood pressure	17.9%
Diastolic blood pressure	11.3%
Hypertriglyceridemia	11.3%
Low HDL	82.8%
Hyperglycemia	54.3%
MetS	61.6%
0 risk factor	0.7%
1 risk factor	10.6%
2 risk factors	27.2%
3 risk factors	42.4%
4 risk factors	16.6%
5 risk factors	2.6%

Table 5: Logistic Regression of MetS for risk factors

Characteristic	B	p	OR	95% CI
Glucose (mg/dl)	0.12	<0.001	1.12	1.08-1.18
HDL (mg/dl)	-0.17	<0.001	0.85	0.78-0.92
Systolic blood pressure (mmHg)	0.09	0.022	1.09	1.01-1.18
Diastolic blood pressure (mmHg)	0.07	0.053	1.07	1.00-1.16
TG (mg/dl)	0.01	0.274	1.01	0.99-1.02
Waist (inches)	-0.03	0.513	0.97	0.88-1.07

TG: triglyceride; B: unstandardized beta, values used in the logistic regression equation; OR: odds ratio; CI: confidence interval; p: 2 tailed p value with significance at <0.05;

Table 6: MetS rate by combining different cardiovascular risk factors

	Have 3 factors (MetS)	Having 2 factors	Having 1 factor	0 factor
WC +HDL+ glu	49.0%	38.4%	11.9%	0.7%
WC+ Bp+ HDL	21.9%	62.9%	15.2%	0.7%
WC+ Bp+ glu	15.2%	48.3%	35.1%	1.3%
Bp+ HDL+ glu	13.2%	46.4%	29.1%	11.3%
WC+ TG+ HDL	10.6%	72.2%	16.6%	0.7%
TG +HDL + glu	7.3%	45.0%	36.4%	11.3%
WC+ TG+ glu	7.3%	51.0%	40.4%	1.3%
WC+ Bp +TG	4.0%	27.8%	66.9%	1.3%
Bp +TG +HDL	4.0%	24.5%	57.6%	13.9%
Bp +TG+ glu	2.6%	18.5%	45.0%	33.8%

WC: high waist circumferences; Bp: hypertension; TG: high triglyceride level; glu: high glucose; HDL: low HDL

differences for MetS by different combinations of the risk factors. The highest MetS rate was 49% which was defined by using the following risk factors: high waist circumference (WC), hyperglycemia, and low HDL. The lowest MetS rate was by combining hypertension, hyperglycemia, and hypertriglyceridemia which only had 2.6%. High WC appeared to be the most important risk factor based on the fact that the highest 3 combinations all had WC as a risk factor. Low HDL was in the top 2 highest combinations. Moreover, permutations with MetS rates less than 10% all included hypertriglyceridemia. Hence, hypertriglyceridemia contributed the least to the MetS rate in this oAAA population.

MetS rate by gender

Percentage of each MetS factors and the total number of factors by gender were shown in Table 7. The average risk factors for oAAA boys and girls were 3 and 2.6 respectively ($p=0.055$) which was close to be significantly different, implying that boys tended to have more risk factors than girls. MetS rate for oAAA boys was 73.1% which was significantly higher than oAAA girls of 55.6% ($p<0.05$). Of all the 5 risk factors, only hypertension differentiated between the genders with boys had significantly higher rate of hypertension than girls, thus hypertension might be able to explain the MetS difference between genders. Moreover, high WC, low HDL, and hyperglycemia were the top three risk factors for both genders which were consistent with the overall result and the rates were not significantly different for these three risk factors between boys and girls.

When all the permutation of the five risk factors were considered, high WC, low HDL and hyperglycemia generated the highest MetS rate for both oAAA boys and girls (Table 8). All the other combinations of MetS rates were less than 17% for oAAA girls and less than 31% for oAAA boys. Hypertriglyceridemia contributed the least for MetS for both genders.

MetS rate by age

The highest risk factors for both Young and Older oAAA groups were high WC, low HDL, and hyperglycemia (Table 9). There were no significantly differences between the two age groups. MetS rate was 64.4% which was higher in the Older group than the Young group of 58.7% but the difference was not statistically significant.

The Young group had a MetS rate of 48.6% when only considering high WC, low HDL and hyperglycemia (Table 10). This result was 30% higher than the second combination which included high WC, hypertension, and low HDL. Similar results were also observed in the Older group.

Specific Aim 2: Examine serum calcium, vitamin D, insulin, leptin and lipid levels in oAAA and compare these blood parameters with national standards

Based on the standard of blood lipid levels for adolescents and children from National Heart, Lung, and Blood Institute (NHLBI), the lipid levels were divided into 3 categories: acceptable range, borderline to high risk, and high risk (Table 11). More than 50% of oAAA had acceptable levels of TC, TG, and LDL level. On the other hand, 89% of the participants had a borderline high or high risk of low HDL levels and more than half of them had a borderline-high or high risk levels of non HDL-C.

Table 7: Cardiovascular risk factor, metabolic syndrome rate and numbers of risk factors by gender in oAAA

Gender	Boys (N=52)	Girls (N=99)	p
High Waist circumference	96%	100%	0.159
Hypertension	35%	19%	0.050
Systolic blood pressure	27%	13%	0.055
Diastolic blood pressure	12%	11%	0.938
Hypertriglyceridemia	17%	8%	0.126
Low HDL	87%	81%	0.379
Hyperglycemia	62%	51%	0.196
Average risk factors	3.0	2.6	0.024
0 risk factor	1.9%	0%	
1 risk factor	7.7%	12.1%	
2 risk factors	17.3%	32.2%	
3 risk factors	44.2%	41.4%	
4 risk factors	23.1%	13.1%	
5 risk factors	5.8%	1.0%	
MetS	73.1%	55.6%	0.03*

Table 8: Top 5 MetS rate by combining different cardiovascular risk factors separate by gender

	Have 3 factors (MetS)	having 2 factors	Having 1 factor	0 factor
BOYS				
WC +HDL+ glu	58%	31%	9%	2%
WC+ Bp+ HDL	31%	58%	9%	2%
WC+ Bp+ glu	21%	54%	21%	4%
Bp+ HDL+ glu	19%	52%	21%	8%
WC+ TG+ HDL	17%	67%	14%	2%
GIRLS				
WC +HDL+ glu	44%	42%	14%	0
WC+ Bp+ HDL	17%	66%	17%	0
WC+ Bp+ glu	12%	46%	42%	0
Bp+ HDL+ glu	10%	44%	33%	13%
WC+ TG+ HDL	7%	75%	18%	0

WC: high waist circumferences; Bp: hypertension; TG: high triglyceride level; glu: high glucose; HDL: low HDL

Table 9: Cardiovascular risk factor, metabolic syndrome rate and numbers of risk factors by age group in oAAA

Age (years)	Young (N=97)	Older (N=54)	p
High Waist circumference	98%	100%	0.158
Hypertension	18%	36%	0.075
Systolic blood pressure	13%	27%	0.075
Diastolic blood pressure	9%	17%	0.335
Hypertriglyceridemia	12%	12%	0.966
Low HDL	80%	85%	0.562
Hyperglycemia	54%	51%	0.913
Average risk factors	2.6	2.8	0.268
0 risk factor	0.9%	0	
1 risk factor	12.8%	6.8%	
2 risk factors	27.5%	28.8%	
3 risk factors	42.2%	42.4%	
4 risk factors	14.7%	18.6%	
5 risk factors	1.8%	3.4%	
MetS	58.7%	64.4%	

Table 10: MetS rate by combining different cardiovascular risk factors separate by age group

	Have 3 factors (MetS)	2 factors	1 factor	0 factor
Young (12-14 years, (N=97)				
WC +HDL+ glu	48.6%	35.8%	14.7%	0.9%
WC+ bp+ HDL	17.4%	62.4%	19.3%	0.9%
Bp+ HDL+ glu	11.0%	44%	31.2%	13.8%
WC+ bp+ glu	11.0%	50.5%	36.7%	1.8%
WC+ TG+ HDL	10.1%	70.6%	18.3%	0.9%
Older (15-16 years,N=54)				
WC +HDL+ glu	42.4%	50.8%	6.8%	0
WC+ bp+ HDL	30.5%	59.3%	10.2%	0
WC+ bp+ glu	18.6%	49.2%	32.2%	0
Bp+ HDL+ glu	13.6%	50.8%	28.8%	6.8%
WC+ TG+ HDL	11.9%	72.9%	15.3%	0

WC: high waist circumferences; Bp: hypertension; TG: high triglyceride level; glu: high glucose; HDL: low HDL

Table 11: Percent of oAAA at acceptable, borderline-high, and high risk lipid levels using National Heart, Lung, and Blood Institute standard

	Acceptable level		Borderline-high risk		High risk	
TC (mg/dl)	<170	69%	170-199	22%	≥200	9%
nonHDL-C (mg/dl)	<120	49%	120-144	27%	≥145	24%
TG (mg/dl)	<90	58%	90-129	24%	≥130	18%
HDL (mg/dl)	>45	11%	40-45	7%	<40	82%
LDL (mg/dl)	<110	58%	110-129	22%	≥130	20%

When comparing the results with the reference values set by NHLBI (Table 12), the average blood lipids levels were significantly lower than the reference ($p's<0.001$). This result suggested that HDL levels were in a high rick range while other lipids levels were in the desired range. Glucose level was higher than the highest suggested reference ($p<0.05$). Suggested reference ranges were given for calcium and 1,25 D3 levels, and both results obtained from oAAA were within the reference range. However, 1,25 D3 level was closer toward the lower end of the reference. 1,25 D3 was negatively correlated with glucose ($r= -0.266$, $p=0.001$) and percentage body fat ($r=-0.190$, $p< 0.05$). No difference was found between mean SBP and standard. However, DBP was lower than the reference value ($p<0.001$). Furthermore, insulin and leptin levels were both significantly higher than the suggested references ($p's<0.001$). Calcium was negatively correlated with TC, non HDL-C, LDL, and TC/HDL ratio (all $p's <0.001$) but no relation was found with HDL.

FPQ and fast food consumption

Knowledge on healthy choices based on Food Picture Questionnaire (FPQ) was represented by the score that adolescents know which food item was healthier than the other. The "healthier" indicates the food options with less fat and sugar contents. Adolescents scored $89.4 \pm 5\%$ on knowledge but only scored $43.7 \pm 19\%$ on preference and $47.5 \pm 17\%$ on the frequency of consumption which implied that they preferred and consumed unhealthier options more often than the healthy choices. Moreover, consumption frequency score was highly correlated with preference ($r=0.379$, $p<0.001$), the more they prefer a healthier food, the more they would consume healthier food. However, no significant correlation was found between knowledge and preference or frequency. Hence, the results indicated that even though they had the nutrition knowledge of the healthiness of food items, food consumption was more affected by preference instead of the knowledge. Preference score was negatively correlated with leptin level ($r=-0.182$, $p<0.05$), the higher the score on preference of healthy food options, the lower the leptin level. However, the preference score was not correlated with either body weight or percentage body fat.

Sixty four percent of oAAA ate at a fast food restaurant once or twice per week (Table 13) and 42% reported it was fewer than an average week. On average, oAAA ate at a fast food restaurant 1.7 ± 1.2 times, range from 0-6 times per week. Even though fast food consumption was not significantly correlated with having MetS, adolescents who consumed more fast food in a week also reported a lower frequency of consuming healthy food from FPQ ($r= -0.214$, $p=0.009$). Moreover, adolescents with more frequent fast food consumption also had a higher body fat percentage ($r =0.176$, $p<0.05$). By combining fast food consumption frequency into 3 groups: 0-1 time/week, 2-3 times/week and ≥ 4times/week, it was observed that both percentage body fat ($F= 3.309$, $p<0.05$) and score of frequency of consumption of healthy food ($F=3.968$, $p<0.05$) showed significant differences among the 3 groups (Table 14). Adolescents who consumed fast food fewer than once a week had a lower percentage of body fat than those who consumed fast food ≥ 4 times per week. They also scored higher in the FPQ frequency (of consuming healthy

Table 12: Comparison between suggested reference values by NHLBI for adolescents and mean blood lipids, blood pressure, glucose, calcium, 1,25 D3, insulin and leptin levels in oAAA

		Suggested reference	p
Systolic blood pressure (mmHg)	121.3 ± 10.2	120	0.108
Diastolic blood pressure (mmHg)	73.9 ± 9.0	80	<0.001
Glucose (mg/dl)	104.7 ± 28.2	< 100	<0.05
Insulin (µU/ml)	74.5 ± 57.5	< 25	<0.001
Leptin (ng/dl)	61.5 ± 25.1	3.9-30	<0.001
Calcium (mg/dl)	9.2 ± 0.7	8.5-10.8	*
1,25 D3 (pg/ml)	46.2 ± 18.0	30-100	*
TG (mg/dl)	93.4 ± 44.8	< 130	<0.001
HDL (mg/dl)	32.1 ± 10.0	> 40	<0.001
TC (mg/dl)	150.4 ± 40.1	< 200	<0.001
Non HDL-C (mg/dl)	118.3 ± 39.6	< 145	<0.001
LDL(mg/dl)	99.6 ± 38.3	< 130	<0.001
HOMA-IR	17.6 ± 12.78	< 2.61	<0.001

*Calcium and 1,25D3 was within the normal range

1,25 D3:1,25-dihydroxyvitamin D; HOMA-IR: homeostatic model assessment of insulin resistance

Table 13: Frequency of eating at a fast food restaurant in the past week

Consumption Frequency	N=151
0 times/week	16.7%
1 times/week	30.7%
2 times/week	32.7%
3 times/week	10.7%
4 times/week	7.3%
5 times/week	1.3%
6 times/week	0.7%
Average	1.7±1.2 (0-6)
More than average week	15.9%
Fewer than average week	42.4%
Same as average week	39.7%
Not applicable	0.7%
Consumption frequency divided into 3 groups	
0-1 time/week	47.3%
2-3 times/week	43.3%
≥4 times/week	9.3%

Table 14: Body fat percentage and frequency score distribution in 3 different fast food consumption groups.

Fast Food consumption	Body Fat percentage	Frequency score
0 -1 time/week	46.5 ± 7.2%*	51.1 ± 17.1%**
2-3 times/week	48.3 ± 6.9%	45.1% ± 16.2%*
≥4 times/week	51.7 ± 7.7%*	39.9% ± 12.7%*

* Significant differences were found among values in the same column ($p<0.05$).

** $p<0.01$

foods) than adolescents in both 2-3/week and ≥ 4/week fast food consumption groups.

Aim 3: Developing a Metabolic Syndrome profile

Comparison of MetS and no MetS in oAAA

As expected, when separating oAAA into MetS group and no MetS group, waist circumferences, glucose, TG, blood pressure and HDL which were used as the risk factors to defining MetS were significantly different between the two groups (p's<0.01). The levels for the first four factors were higher ($p<0.05$, Table 15) and HDL was significantly lower in MetS group ($p<0.001$) when compared to the no MetS group. Furthermore, MetS group had higher BMI, BMI z score, body weight and waist to hip ratio (p's<0.05). However, no significant difference in BMI percentile, height and percentage body fat as compared to the no MetS group. MetS group also had higher insulin and insulin resistance as calculated by HOMA-IR ($p <0.001$). However, 1,25 D3 and calcium (both $p<0.05$) levels were lower relative to the no MetS group. No significant differences were found in TC, non HDL-C, LDL and leptin levels between the two groups.

The results from BFFQ were presented in three tables. Table 16 compared energy and macronutrient intakes in oAAA with and no MetS. OAAA with and without MetS consumed similar amount of energy and had similar distribution of energy from the three main energy sources. Furthermore, results for sugar intake, different fat sources, cholesterol, energy from sugary beverages and dietary fiber did not show significant differences in oAAA with or without MetS. However, percentage energy from protein was significantly higher for oAAA who had MetS than those without MetS (p<0.05).

No significant differences were found in the dietary mineral and vitamin intakes (Table 17). Nevertheless, vitamin C intake tended to be higher in the without MetS group than that in the MetS group (p=0.059). This might be explained by the result of the daily servings of the different food groups (Table 18). There was a trend that daily fruit and fruit juice consumption was higher for oAAA without MetS (p=0.087) and there was no difference between the 2 groups on intakes of other food groups.

The results in this study showed that higher dietary intakes of protein and total fat were associated with a higher BMI, (r=0.190, p=0.028; r=0.226, p=0.009 respectively). Among different types of dietary fatty acids, saturated fatty acids (r=0.242, p=0.005), monounsaturated fatty acids (r=0.234, p=0.007) and trans fatty acids (r=0.197, p=0.023) were correlated with BMI but polyunsaturated fatty acids were not. Dietary cholesterol (r=0.213, p=0.014) was also positively correlated with BMI. Furthermore, dietary total fat was positively correlated with fast food consumption (r=0.194, p=0.026) and leptin level (r= 0.196, p=0.023), and close to be significant with percentage body fat (r=0.170, p=0.52).

A negatively correlation was found between total fat intake and consumption preference (of healthy foods) score (r= -0.217, p=0.012) which indicated that oAAA who scored higher on preferring healthy food consumed less total fat. OAAA with higher saturated fat intake also showed higher percentage body fat (r=0.185, p=0.034) and higher fast food consumption (r=0.178, p=0.041). Dietary trans fatty acids correlated with percentage of body fat (r=0.180, p=0.028).

Table 15: Comparison of anthropometric characteristics and blood parameters between MetS and No MetS groups

	MetS (n=93)	No MetS (n=58)	p
Age	14.3 ± 1.4	14.2 ± 1.4	0.431
BMI	38.3 ± 7.7	36.0 ± 6.1	<0.05
BMI percentile	98.9 ± 1.0	98.6 ± 1.2	0.072
BMI z score	2.4 ± 0.3	2.3 ± 0.3	<0.05
Weight (lb)	232.1 ± 49.9	213.3 ± 40.5	<0.05
Height (inches)	65.3 ± 2.8	64.5 ± 2.7	0.07
Waist (inches)	44.4 ± 6.2	42.0 ± 5.4	<0.05
Hip (inches)	48.8 ± 7.1	46.6 ± 4.3	<0.05
WHR	0.92 ±0.07	0.90 ± 0.07	0.161
Percentage body fat	48.6 ± 7.6	46.4 ± 6.3	0.07
Systolic blood pressure (mmHg)	123.7 ± 8.9	117.4 ± 8.0	<0.001
Diastolic blood pressure (mmHg)	75.2 ± 9.0	71.5 ± 7.4	<0.05
Glucose (mg/dl)	113.2 ± 19.9	87.1 ± 13.5	<0.001
TG (mg/dl)	98.0 ± 42.0	78.9 ± 33.4	<0.01
HDL (mg/dl)	28.5 ± 7.2	36.8 ± 10.2	<0.001
TC (mg/dl)	151.5 ± 40.2	148.7 ± 38.0	0.665
Non HDL-C (mg/dl)	123.0 ±40.5	111.9 ± 36.0	0.090
LDL (mg/dl)	103.4 ± 39.8	96.1 ± 33.8	0.249

Table 15: Comparison of anthropometric characteristics and blood parameters between MetS and No MetS groups (Cont'd)

Insulin (µU/ml)	73.3 ±42.4	56.7 ± 30.9	<0.05
Leptin (ng/ml)	62.3 ± 24.5	60.4 ± 23.6	0.642
Insulin Resistance HOMA	20.8 ± 14.0	12.5 ± 8.3	<0.001
Calcium (mg/dl)	9.1 ± 0.8	9.4 ± 0.7	<0.05
1,25 D3 (pg/ml)	43.5 ± 16.6	51.2 ± 19.5	<0.05

WHR: waist to hip ratio; 1,25 D3:1,25 dihydroxy Vitamin D

Table 16: Comparison of macronutrient and energy intakes of oAAA with and without MetS

	MetS (n=84)	w/o MetS (n=49)	p
Total Kcal	1296 ± 558	1334 ± 634	0.713
Kcal from sugary beverages	138 ± 150	161 ± 161	0.397
Percent Kcal from fat	33.8% ± 6.4	32.4% ± 8.2	0.271
Percent Kcal from protein	14.3% ± 3.7	13.0% ± 3	0.035
Percent Kcal from CHO	53.5% ± 9.7	56.6% ± 10.8	0.086
Percent Kcal from sweets	12.2 % ± 8.9	12.9% ± 8.8%	0.694
Protein (g)	46 ± 23	43 ± 22	0.716
Total Fat (g)	49 ± 24	48 ± 25	0.854
CHO (g)	173 ± 79	190 ± 100	0.302
Sugar (g)	96 ± 53	114 ± 75	0.100
Saturated fat (g)	16 ± 8	15 ± 8	0.651
Monounsaturated fat (g)	19 ± 9	18 ± 9	0.709
Polyunsaturated fat (g)	10 ± 6	10 ± 7	0.600
Trans fat (g)	4 ± 3	4 ± 2	0.886
Cholesterol (mg)	146 ± 86	135 ± 93	0.489
Dietary fiber (g)	10 ± 5	11 ± 6	0.360

Table 17: Comparison of vitamin and mineral intakes of oAAA with and without MetS

	MetS (n=84)	w/o MetS (n=49)	p
Minerals			
Calcium (mg)	556.4 ± 290.6	544.0 ± 342.3	0.824
Iron (mg)	9.6 ± 4.6	9.0 ± 4.5	0.425
Magnesium (mg)	158.6 ± 74.3	169.3 ± 92.0	0.466
Potassium(mg)	1575.1 ± 75.2	1664.3 ± 946.2	0.544
Phosephorus (mg)	782.3 ± 344.3	770.4 ± 421.9	0.860
Sodium (mg)	2016 ± 1062	1893 ± 890	0.495
Zinc (mg)	7.5 ± 3.7	6.7 ± 3.5	0.273
Vitamins			
Vitamin A (mcg)	396.6 ± 240.6	370.2 ± 236.0	0.539
Thiamin (mg)	1.04 ± 0.45	1.0 ± 0.50	0.651
Riboflavin (mg)	1.27 ± 0.55	1.19 ± 0.67	0.466
Niacin (mg)	13.5 ± 6.4	12.0 ± 6.0	0.195
Vitamin B6 (mg)	1.2 ± 0.5	1.1 ± 0.6	0.342
Vitamin B12 (mcg)	3.1 ± 1.7	2.7 ± 1.7	0.232
Vitamin C (mg)	90.8 ± 76.5	125.2 ± 111.0	0.059*
Vitamin D (IU)	105.3 ± 74.5	96.1 ± 89.8	0.524
Vitamin E (mg)	4.8 ± 3.9	5.4 ± 4.8	0.434
Folate (DFE)	342.1± 172.4	313.4 ± 158.3	0.340
Vitamin K (mcg)	60.6 ± 66.0	64.7 ± 60.3	0.720

Table 18: Comparison of daily servings from food groups of oAAA with and without MetS

	MetS (n=84)	w/o MetS (n=49)	p
Daily vegetable serving	1.3 ± 1.5	1.1 ± 1.0	0.472
Daily fruit & fruit juice	1.0 ± 0.9	1.4 ± 1.3	0.087
Daily Grain serving (breads, cereals, rice, pasta)	3.1 ± 1.7	2.8 ± 1.8	0.369
Daily Meat serving (meat, fish, poultry, beans, eggs)	1.5 ± 1.0	1.4 ± 0.8	0.517
Daily Dairy serving (milk, yogurt, cheese)	1.0 ± 0.8	1.0 ± 0.9	0.781
Daily Fat serving (fats, oils, sweets, sodas)	2.4 ± 1.3	2.5 ± 1.4	0.614

After conducting a partial correlation by controlling BMI, fast food consumption was only significantly correlated with dietary cholesterol intake (r=0.188, p=0.031). OAAA who reported consuming healthy food more frequently also reported a higher dietary potassium, vitamin C and fiber intake (r= 0.172, p=0.047; r= 0.186, p=0.032; r= 0.299, p< 0.001 respectively). Furthermore, the higher they scored on preference of healthy foods the less their dietary cholesterol intake was (r = -0.179, p=0.039). However no correlation was found between nutrition knowledge, home food environment score and the dietary intake of all the nutrients.

All the measurements were entered as independent variables in a logistic regression model to examine their relationships with MetS. Since TC, non HDL-C, LDL were highly correlated (r > ±0.80), so were insulin and HOMA-IR, only LDL and HOMA-IR were used in the analysis to avoid the collinearity of these variables in the regression model. The test of the full model (using all the variables) against the null model (null hypothesis of everyone having MetS) was significantly better, indicating that the variables as a set reliably distinguished having or not having MetS in oAAA (x^2=24.52, df=14, p<0.000) (Table 19). The full model classified oAAA of Met improved from 65.5% to 71.2%. HOMA-IR and TC/HDL ratio were positively and 1,25 D3 was negatively contributing to MetS. With one unit change of these variables the odds of MetS changed by +9.6%, +55.4% and – 2.5% respectively. Calcium approached significance for having a negative effect.

Since not all of these variables significantly predicted MetS in the overall oAAA, potential gender and age differences were tested. The same variables were used to perform logistic regression for oAAA girls. The test of the full model against the null model was significantly better, indicating that the variables as a set reliably distinguished having or not having MetS in oAAA girls (x^2=26.51, df=14, p<0.05) (Table 20). The full model classified oAAA girls as having MetS improved from 51.8% to 73.1%. HOMA-IR contributed to MetS in oAAA girls and with each unit increase, odds of having MetS increased by 9%. However, the equation cannot be established in oAAA boys due to the number of boys without MetS was fewer than the independent variables. For oAAA in the Young group, the test of the full model against the null model was significantly better, indicating that the variables as a set reliably distinguished having or not having MetS in Young group oAAA (x^2=39.83, df=14, p<0.000) (Table 21). The full model classified oAAA in the Young group of MetS improved from 74.1% to 85.9%. TC/HDL ratio and HOMA-IR positively contributed to MetS with 18% and 17% increase in odds ratio for each unit increase respectively. Moreover, for each unit increase in 1,25 D3, LDL, and food environment score, the odds of having MetS decreased by 4%, 3%, and 98% respectively. However, the sample size was small for the Older group and the overall model fit for Older group was not significant (p=0.111) (result not shown).

Principal component analysis was conducted for the entire oAAA to group all the variables into different clusters so the variables in each cluster are interrelated. The result yielded 6 clusters that explained 72.3% of the total variance (Table 22).

Table 19: Odds Ratios of anthropometric data, lipid profile, leptin, calcium, 1,25 D3 and insulin resistance and nutrition related factors for MetS in oAAA based on logistic regression analysis

Characteristic	**B**	**p**	**OR**	**95%CI**
BMI	0.018	0.693	1.02	0.93-1.11
WHR	-2.347	0.505	0.10	0.00-94.61
Percentage body fat	0.039	0.407	1.04	0.95-1.14
TC/HDL ratio	0.441	0.043	1.55	1.02-2.38
LDL (mg/dl)	-0.008	0.417	0.99	0.97-1.01
Leptin (ng/ml)	-0.016	0.150	0.98	0.96-1.01
Calcium (mg/dl)	-0.634	0.072	0.53	0.27-1.06
1,25 D3 (pg/ml)	-0.025	0.042	0.98	0.95-1.00
HOMA-IR	0.092	0.007	1.10	1.03-1.17
Fast food consumption	0.03	0.872	1.03	0.72-1.48
Preference score	-0.356	0.788	0.70	0.52-9.40
Frequency score	-0.334	0.817	0.72	0.04-12.09
Nutrition knowledge	-0.218	0.959	0.80	0.00-3557.52
Food environment score	-1.002	0.411	0.37	0.03-4.00

1,25 D3: 1,25 dihydroxyvitamin D; B: unstandardized beta, values used in the logistic regression equation; CI: confidence interval; OR: odds ratio; WHR: waist and hip ratio; TC: total cholesterol; HOMA-IR: homeostatic model assessment insulin resistance; p: 2 tailed p value with significant at <0.05

Table 20: Odds Ratios of anthropometric data, lipid profile, leptin, calcium, 1,25 D3 and insulin resistance and nutrition related factors for MetS in oAAA girls

Characteristic	B	p	OR	95% CI
BMI	-0.066	0.343	0.94	0.82-1.07
WHR	-0.649	0.888	0.52	0.0-4250
Percentage body fat	0.111	0.133	1.12	0.97-1.29
Fast food consumption	0.111	0.640	1.12	0.70-1.78
Calcium (mg/dl)	-0.616	0.141	0.54	0.24-1.23
1,25 D3 (pg/ml)	-0.021	0.145	0.98	0.95-1.01
Leptin (ng/ml)	-0.005	0.722	1.00	0.97-1.02
TC/HDL ratio	0.338	0.157	1.40	0.88-2.24
LDL (mg/dl)	-0.008	0.525	0.99	0.97-1.02
HOMA-IR	0.083	0.018	1.09	1.01-1.17
Preference score	-0.522	0.074	0.59	0.03-12.93
Frequency score	-0.742	0.648	0.48	0.02-11.49
Nutrition knowledge	0.457	0.925	1.58	0-22456
Food environment score	-0.284	0.831	0.75	0.06-10.21

1,25 D3: 1,25 dihydroxyvitamin D; B: unstandardized beta, values used in the logistic regression equation; CI: confidence interval; OR: odds ratio; WHR, waist and hip ratio; TC: total cholesterol; HOMA-IR: homeostatic model assessment insulin resistance; p: 2 tailed p value with significant at <0.05

Table 21: Odds Ratios of anthropometric data, lipid profile, leptin, calcium, 1,25 D3 and insulin resistance and nutrition related factors for MetS in oAAA Young group

Characteristic	B	p	OR	95%CI
BMI	0.120	0.135	1.13	0.96-1.32
WHR	-3.924	0.470	0.02	0.00-830.73
Percentage body fat	-0.039	0.603	0.96	0.83-1.12
Fast food consumption	0.188	0.507	1.21	0.69-2.10
Calcium (mg/dl)	-0.788	0.167	0.46	0.15-1.39
1,25 D3 (pg/ml)	-0.043	0.019	0.96	0.92-0.99
Leptin (ng/ml)	-0.026	0.135	0.97	0.94-1.01
TC/HDL ratio	1.032	0.011	2.81	1.26-6.24
LDL (mg/dl)	-0.034	0.045	0.97	0.94-1.00
HOMA-IR	0.159	0.028	1.17	1.02-1.35
Preference score	1.275	0.534	3.58	0.07-197.70
Frequency score	0.851	0.693	2.34	0.04-158.77
Nutrition knowledge	2.555	0.746	12.9	0-67509009
Food environment score	-3.959	0.039	0.02	0.00-0.82

1,25 D3: 1,25 dihydroxyvitamin D; B: unstandardized beta, values used in the logistic regression equation; CI: confidence interval; OR: odds ratio; WHR: waist and hip ratio; TC: total cholesterol; HOMA-IR: homeostatic model assessment insulin resistance; p: 2 tailed p value with significant at <0.05

Table 22: Factor loadings of all variables for MetS after varimax rotation for oAAA*

	Factors					
	1	2	3	4	5	6
TC (mg/dl)	0.952					
LDL (mg/dl)	0.969					
Non HDL-C (mg/dl)	0.981					
TC/HDL ratio	0.838					
Calcium (mg/dl)	-0.592					
BMI		0.843				
Percentage of body fat (%)		0.885				
Leptin (ng/ml)		0.735				
Insulin (µU/ml)			0.957			
HOMA-IR			0.963			
WHR			0.465			
Preference score				0.785		
Frequency score				0.815		
Nutrition knowledge					0.748	
1,25 D3 (pg/ml)					-0.574	-0.436
Fast food consumption					0.487	
Food environment score						0.836
Variance explained (%)	23.4	16.6	10.6	9.0	6.7	6.0
Cumulative variance (%)	23.4	40.0	50.6	59.6	66.3	72.3

1,25 D3: 1,25 dyhydroxyvitamin D; WHR: waist and hip ratio; TC: total cholesterol; HOMA-IR: homeostatic model assessment insulin resistance

The cutoff point for the factor loadings was 0.30 and was based on the research of cardiovascular risk factor clustering in Bogalusa study (77). All the lipid profile (TC, LDL, non HDL-C and TC/HDL) were positively loaded and calcium was negatively loaded on cluster 1, and was defined as the lipids + calcium cluster. Cluster 2 was loaded positively with BMI, percentage body fat, leptin and WHR which was defined as body fat related cluster.

Cluster 3 was loaded positively with WHR, insulin and HOMA-IR and was defined as insulin resistance related cluster. Cluster 4 was loaded positively with preference score, frequency score and negatively with fast food consumption, and was defined as the food pattern cluster. Nutrition knowledge and fast food consumption were positively loaded and 1,25 D3 was negatively loaded in cluster 5 and was defined as the knowledge + vitamin D factor. Food environment score was positively loaded in cluster 6 while 1,25 D3, and WHR was negatively loaded in cluster 6, and cluster 6 was defined as food environment factor.

For the entire oAAA population, the test of the full model against the null model was significantly better, indicating that the clusters as a set reliably distinguished having or not having MetS in oAAA (x^2=24.5, df=6, p<0.000) (Table 23). The full model classified oAAA of MetS improved from 65.5% to 71.2%.Three out of the 6 clusters were significant. Lipids + calcium cluster, insulin resistance related cluster and nutrition knowledge cluster were positively contributed to the odds of MetS, and the odds of MetS increased by 66.5%, 128.5% and 64.8% for each unit increase of these clusters respectively. Since the small sample size was identified in oAAA boys and Older groups, no significant difference was observed in logistic regressions.

Logistic regression was conducted in oAAA girls using the 6 cluster scores identified from the entire oAAA population to predict how well these clusters explained MetS in oAAA girls. The test of the full model against the null model was significantly better, indicted that the clusters as a set reliably distinguished having or not having MetS in oAAA girls (x^2=13.76, df=6, p<0.05) (Table 24). The full model predicted oAAA girls with MetS improved from 58.1% to 66.7%. With one unit increase of insulin resistance related cluster, the odds of MetS increased by 107%.

The 6 clusters were also applied to the Young group of oAAA. The test of the full model against the null model was significantly better, indicated that the clusters as a set reliably distinguished having or not having MetS in Young group oAAA (x^2=17.55, df=6, p<0.01) (Table 25). The full model identified oAAA Young with MetS improved from 65.9% to 72.9%. With one unit increase of insulin related cluster and nutrition knowledge+ vitamin D cluster, the odds of MetS increased by 179% and 110%.

Table 23: Odds Ratios for MetS in oAAA based on the 6 clusters identified by principal component analysis

Clusters	B	p	OR	95% CI
Lipids + calcium	0.510	0.014	1.665	1.11-2.50
Body fat related	0.157	0.436	1.170	0.79-1.74
Insulin resistance related	0.826	0.003	2.285	1.32-3.94
Food pattern	-0.177	0.368	0.837	0.57-1.23
Nutrition knowledge+ vitamin D	0.499	0.023	1.648	1.07-2.54
Food environment	-0.056	0.773	0.945	0.65-1.39

B: unstandardized beta, values used in the logistic regression equation; CI: confidence interval; OR: odds ratio

Table 24: Odds Ratios for MetS in oAAA girls based on the 6 clusters identified by principal component analysis

Factors	B	p	OR	95% CI
Lipids + calcium	0.361	0.128	1.44	0.90-2.29
Body fat related	0.162	0.549	1.18	0.69-2.00
Insulin resistance related	0.729	0.016	2.07	1.15-3.74
Food pattern	-0.246	0.349	0.78	0.47-1.31
Nutrition knowledge + vitamin D	0.488	0.061	1.63	0.98-2.71
Food environment	-0.018	0.932	0.98	0.65-1.49

B: unstandardized beta, values used in the logistic regression equation; CI: confidence interval; OR: odds ratio

Table 25: Odds Ratios for MetS in oAAA Young Group based on the 6 clusters identified by principal component analysis

Characteristic	B	p	OR	95% CI
Lipids + calcium	0.372	0.201	1.45	0.82-2.57
Body fat related	0.138	0.615	1.15	0.67-1.97
Insulin resistance related	1.027	0.011	2.79	1.26-6.18
Food pattern	0.057	0.838	1.06	0.61-1.83
Nutrition knowledge+ vitamin D	0.744	0.020	2.10	1.12-3.94
Food environment	-0.300	0.255	0.74	0.44-1.24

B: unstandardized beta, values used in the logistic regression equation; CI: confidence interval; OR: odds ratio

CHAPTER 4

DISCUSSION

MetS Rate Using IDF Criteria

The current study was the first study to investigate MetS in oAAA population in the metropolitan area by using the IDF criteria for MetS. The IDF defines MetS as a constellation of symptoms including any three of the following 5 characters: high WC, hyperglycemia, hypertension, hypertriglycedemia and low HDL. Based on this definition, the MetS rate in this oAAA population was 61.6%. Since our study included only 151 participants, MetS rate would be used instead of prevalence to describe our results, and the word prevalence would be used for other large scale population studies, such as the NHANES study. The results obtained agree with our hypothesis that oAAA had high rates of MetS using the IDF criteria. MetS rate was higher in oAAA (61.6%) when compared to other obese population and ethnicities. A study in Spain reported 80.4% of the obese adolescents had 1 or 2 risk factors, and a 19.6% MetS rate using the IDF criteria (78). Another study in China investigated MetS prevalence in 20,000 school age children ranged from 7-18 years and reported MetS prevalence of 29.8% based on the IDF criteria (79). In our current oAAA, high WC had the highest occurence at 98.7% and hypertriglyceridemia had the lowest occurrence at 11.3%. In the US adolescents population there were different prevalence for each of these 5 risk factors, hypertriglyceridemia had the highest prevalence of 25.6% and hypertension was the lowest with 6.9% prevalence (36). The rates of having these risk factors were higher in oAAA. Furthermore, non-Hispanic black adolescents had the obesity prevalence of 22.1%, only slightly lower than the Hispanic adolescents of 22.6% (3). Therefore, oAAA had high prevalence of obesity, all the metabolic risk factors, and MetS by using the new IDF criteria.

This study observed that the combination of high WC, low HDL, and hyperglycemia contributed to the highest MetS rate in oAAA population regardless of gender and age. However, the results of logistic regression analyses revealed significant contributions only from glucose and HDL affected the odds ratio of MetS, and no significant contribution was found from WC. WC was highly associated with central and abdominal fat and was a better indicator of abdominal obesity than BMI percentile in youth (80). Therefore, the obese population is expected to have a higher prevalence of high WC. In our current study, with the exception of 2 participants, all of the oAAA (98.7%) had high WC, thus WC may not be a reliable predictor to distinguish presence of MetS in this population. Similar results were also found in the Anatolia adolescent population. Even though this study used modified Adult Treatment Panel III criteria to define MetS, which used HOMA-IR instead of glucose level, they also reported low HDL and high insulin resistance were the most common risk factors for MetS (81).

Adolescent boys had higher MetS rate than girls regardless of BMI. Laurson et al. investigated MetS in obese adolescents in the US by combining the NHANES data sets from 1999 to 2008, and reported higher MetS in boys (82). Prevalence of high TG, high glucose, and hypertension were all higher in obese boys than girls. Another study conducted in Europe with children and adolestcents from Brazil, Iran, and Germany also reported higher MetS in boys than girls (83). These results were consistent with the results from our study that oAAA boys had only a slightly higher MetS rate and more risk factors than oAAA girls. However, Johnson et al. reported Black adolescent boys only had a slightly higher MetS prevalence than girls (3.9% vs 4.2% respectively) in the US when using the criteria developed by Ford, which used age and gender specific BP >90th percentile instead of 130/85mmHg as cutoff points (35, 36). The difference of MetS between boys and girls in this study seemed to be caused by the difference in high WC (11.9% vs 23.3%) between boys and girls. However, in the present study, hypertension was found to be the contributing factor for the gender difference. The difference in the results between our current study and that of the Johnson et al. stressed the important role hypertension plays in creating the gender difference. When different criteria for adolescent hypertension are used, the gender difference in MetS may no longer exist.

Lipid Profile

Based on the NHLBI guidelines for cardiovascular health in children and adolescents, high levels of TC, non HDL-C, TG, and LDL, and low levels of HDL are all risk factors of cardiovascular disease (76). Eighty two percent of the oAAA were at high risk level for low HDL and whereas only (what %) of oAAA were in the high risk range for other lipids levels. However, the lipid profile from our study suggested all the mean lipid levels were significantly lower than the suggested references. Another study also reported that serum lipid levels in obese US youths age 6-19 years were within the acceptable range; in fact levels of TC, non-HDL C, LDL, and TG levels declined from 1988 to 2010 (84). Carr et al. stated that individuals with MetS tend to have a relatively normal level of LDL and the increased number of small and dense LDL particles are more related to abdominal fat and CVD risks (85). In our study, we did not measure the LDL particle size hence we could not make any inferences about the effects of LDL particle size on MetS. However, based on the fact that 98.7% of the oAAA had high WC, it is speculated that they all might have small LDL particles. Further study to measure the LDL particle size in oAAA is therefore warranted.

Leptin level

Serum leptin levels were strongly correlated with BMI and percentage of body fat both in adults and in children (86-88). An adult study that investigated the differences of leptin between obese and healthy weight subjects reported serum leptin concentration was 31.3 ± 24.1 ng/ml in the obese subjects and 7.5 ± 9.3 ng/ml for healthy weight subjects (87). Baseline data from a weight loss intervention trial for obese children with mean age of 13.9 years old showed a mean leptin level of 39.5 ± 23.7ng/ml before the weight loss. The leptin levels were extremely high in our study population not only compared to the suggested reference but also to other studies (86, 87). With the high percentage high body fat and WC in our study population (Table 3), high leptin levels would be expected. Additionally, no significant differences were found between MetS and without Mets groups in leptin levels, which suggests that leptin may not be a good predictor for MetS in a population with high WC levels in each individual.

1,25 D3 and Calcium

Dietary Vitamin D intake in both MetS and without MetS oAAA (105.3 ± 74.5 and 96.1 ± 89.8 IU) were significantly lower than the Dietary Reference Intake (DRI) for vitamin D. The DRI for vitamin D was increased from 400IU to 600 IU per day in 2011 by Institute of Medicine (89). This change was made considering the minimum sun exposure of certain areas in the US. Exposure to sunlight was the major source of vitamin D for humans. The other source for vitamin D is dietary consumption. However, increased skin pigmentation can dramatically decrease the vitamin D3 synthesis (90, 91). African Americans with really dark skin reduced 99% of the ability to synthesize vitaminD3 (90). Therefore, African Americans are more likely than other populations with less skin pigments to have vitamin D deficiency. Epidemiology data based on the 2003-2006 NHANSE study also suggested African American children and adolescents have the highest vitamin D deficiency prevalence amount all other ethnic groups, with 68% in African American children, 38% in Latinos and 12% in Whites (53).

Serum 1,25 D3 level in oAAA was within the suggested range despite toward the lower end. Vitamin D from the diet or synthesized through the skin is converted to 25-hydroxyvitamin D (25-D) which is the storage form and it is usually used to test vitamin D deficiency in humans (92). The 25-D is then converted into the bioactive form 1,25 D3 by 25-hydorxyvitamin D-1-α-hydroxylase in the kidneys. This process is regulated by parathyroid hormone (PTH). When calcium level is low in the blood, parathyroid glands releases PTH and PTH passes the signal to kidneys so more 1,25 D3 is released into the blood. The elevated PTH and 1,25 D3 together increase calcium absorption from intestine and regulate the osteoclast/osteoblast ratio in the bone so more calcium will be released from the bone storage and blood calcium levels are restored (92). When blood calcium is sufficient, the process is down regulated and the level of PTH and 1,25 D3 decrease. Therefore, the sufficient amount of 1,25 D3 in the blood could have been the results of regulation of normal PTH secretion and serum calcium in oAAA population. It also implies that the kidney functions in this oAAA population are normal so the conversion of 25 D to 1,25 D3 can be accomplished normally.

Moreover, PTH is positively related to body fat in African American (AA) adults, and higher PTH levels caused higher 1,25 D3 levels were observed in obese AA compared to lean AA adults (93). Even though we did not measure PTH levels in the current study, our results indirectly support these findings and extended these findings into adolescent population. However, a more recent (2006) cross-section study reported a lower level of 1,25 D3 in obese than in non-obese in both AA and White adults (52). Limited results were reported in adolescent and children population. The research, conducted by Rajakumar and colleagues (94), reported serum 1,25 D3 level of 49.9 ± 22.0 pg/dl for obese AA children and no difference was found when comparing with non-obese children. Considering all these conflict results reported about 1,25 D3 in obese adolescents, further studies with a larger population are warranted.

Even though serum calcium levels were in the desirable range in oAAA both with and without MetS, it was significantly higher in oAAA without MetS. The DRI for calcium is 1100 mg per day for children age 9-18 (89). Our results revealed a low calcium intake but serum calcium levels were within the suggested range. Serum calcium level can be maintained by calcium reabsorption in the kidneys, increased intestine calcium absorption, and increased calcium release from osteoclast cells (95). Since calcium intake was low in oAAA, the secretion of PTH should have been high to increase calcium absorption from the small intestine and release from bone cells to achieve the homeostatic level of serum calcium. A paradox exists among African Americans related to vitamin D levels and osteoporosis. Based on the National Osteoporosis Risk Assessment study, Blacks had lower blood calcium levels but also lower prevalence of osteoporosis and fracture risks than Whites in postmenopausal women (96). The paradox could be explained by ethnic difference of body composition and genetics. African American adults have higher bone mass when compared to other ethnicities in Brookhaven National Laboratory study (97). Nelson and colleagues reported a significant difference of vitamin D receptor genotype between African Americans and Whites (98). The Whites in this study had the genotype that was related to less bone mass. Our study results may add to this paradox in that in oAAA, a low calcium intake did not produce low blood calcium levels, implying that increased calcium absorption or reabsorption may have occurred.

Food Picture Questionnaires (FPQ)

OAAA in our study reported a close to 90% accuracy on identifying healthy food; however, the consumption score and preference score was only close to 50% in both MetS and without MetS groups. This identified a discrepancy between knowledge and eating behavior regardless of MetS status in oAAA. A focus group study including 141 adolescents with multicultural background were asked to identify factors that affected their eating patterns. Findings included convenience of food, accessibility of food, family influence on eating behaviors, such as cultural and regional differences, craving, and cost (99). Two of the food choice barriers identified in this study were taste preferences of the food and lack of urgency about personal choice in relation to health outcomes. These 2 barriers might also be applied to our study population. Our participants were mostly referred and recruited from DMC clinics, indicating that they either had some health conditions or they were screened by their primary health providers and referred to the study. Therefore, they were aware of their health issues. Despite of this awareness, these oAAA still did not apply their knowledge in their daily life. It is urgent to identify motivational factors so these oAAA would overcome the barriers and practice a healthy lifestyle using the knowledge they already possessed.

Since adolescents are not completely independent, their eating behavior and dietary pattern are strongly influenced by parents or caregivers. If the caregivers do not provide their children with healthy foods at home, then it will be difficult for the children with knowledge to consume healthy foods. These may help explain the inconsistency between nutrition knowledge, consumption score, and preference score as well as the correlation between consumption and preference. This correlation could either imply that oAAA consumed unhealthier food more often so they preferred it, or oAAA preferred the unhealthier food so they consumed it more often. Since oAAA chose their foods based on their preference rather than healthiness when consuming them, increasing the appearance, taste, exposure and accessibility of healthy food might increase healthy food consumption in oAAA population.

Fast Food Consumption

Fast food consumption was not significantly different in oAAA with and without MetS, and more frequent fast food consumption was correlated with higher percentage of body fat and lower frequency of healthy food consumption based on the FPQ. Since the FPQ was not designed to examine fast food consumption, the result showed consistency with eating pattern and reports of fast food consumption. Fast foods have always been associated with higher fat and cholesterol content, as well as added sugar. However, some studies have shown that fast food intake maybe not act alone. Based on a study by Ritchie et al with a female population in 2007, consumption of 40 different food groups were categorized into different food patterns (100). While fast food pattern was considered as the sources of high energy, fat, and cholesterol diet for White girls, the sources of high energy, and fat for AA girls were snack foods and sweets + cheese pattern. Hence there is a racial difference regarding the sources of the high energy, fat and cholesterol foods. Furthermore, a recent study used 2009- 2010 NHANSE data and reported that the amount of calories from added sugars and solid fat were not different among the foods from fast food restaurants, schools and stores, which were 35%, 32% and 33% respectively, in 3,077 US children and adolescents aged 2-18 year (62). Therefore, the study of additional eating patterns and food sources in adolescents may provide greater insight in the eating pattern risks for MetS.

Food Environment Questionnaire (FEQ)

Even though adolescents in the focus group identified their eating patterns were affected by environment such as food accessibility and availability at home (99), there were no difference found in food environment score and total energy intake, frequency score, and preference in our study. More healthy food at home didn't always increase the intake of these healthy foods or improve total energy intake. Based on parent reports, cite here, observed that non-Hispanic black adolescent households had more products with regular fat content compared to…. In the same study with biracial populations, they also reported lack of significant relationships between the home availability of fruit, vegetables and fat and food consumption (101). Thus…explain more overtly the point you want to make on that. Since adolescents were in the transition stage of eating less at home and started socializing and dining out with friends more often, adolescents reported less energy intake from home and increased proportion of energy from dinning out especially from fast food places and restaurants (102). This study also pointed out that the increased energy intake for adolescents mainly came from snacking occasions. The FEQ used in this study only contained questions related to the home environment, more food environment factors such as school meal, dining out, snacking occasions outside of the house should be taking into consideration while trying to evaluate MetS in oAAA in the future.

Block Food Frequency Questionnaires (BFFQ)

Block Food Frequency Questionnaire is a commonly used method to assess dietary intake patterns. The benefits of using it are the simplicity of collecting data and the shorter duration to complete the questionnaire (103). Our results showed a positive correlation between total fat intake and BMI as well as with fast food consumption. OAAA with a higher BMI needed to consume more energy to maintain their body weight, and higher energy intake also meant higher fat, protein and CHO consumption since there are the main dietary energy sources in food. So in order to take into consideration of the interrelationships, partial correlation analyses were conducted and revealed that fast food consumption was only significantly correlated with dietary cholesterol intake. Even though preference score and frequency score (of consumption of healthy foods) were correlated in oAAA, there were still different in the relationship with dietary intake. OAAA with higher preference score consumed less total fat and cholesterol in the diet. OAAA with higher frequency score reported higher dietary intake of potassium, vitamin C and fiber. No significant differences of the dietary intakes from BFFQ were found in oAAA with MetS and without MetS.

MetS profile

When evaluating each individual variable in the logistic regression model, HOMA-IR increased the odds of MetS for overall oAAA, oAAA girls and young oAAA. TC/HDL ratio increased, and 1,25 D3 decreased the odds of MetS for overall oAAA and Young group oAAA (Table 19-21). LDL and food environment score only decreased the odds of MetS in Young group oAAA. These result indicated that HOMA-IR was the only significant predictor for MetS for oAAA girls. Food environment score predicted MetS only in the Young group only. These interesting findings suggested that with an increase in healthy food and decrease in unhealthy food options at home, the odds of having MetS would be decreased. A longitudinal study, Project EAT, reported a decrease in fruit, vegetable, and diary consumption after a 5 year follow up in adolescents (12 years old at baseline and 17 at time 2) (104). As adolescents grown older, they consumed more meals outside of the house. Therefore, the home food environment was more important for affecting the food intake pattern in young rather than in older oAAA.

Since there were many interrelated variables measured in the study and any one of them could have an impact in the development of MetS, principle component factor analysis was conducted to group all the variables into clusters. The analysis for all oAAA generated 6 clusters of components (factors) and each component included different number of variables. The factor loading was conducted with varimax rotation which prevents each component from correlated with each other. Among the 6 clusters identified in oAAA, MetS was better predicted by lipids +calcium factor, insulin resistance related factor, and nutrition knowledge + vitamin D factor. The result in our study showed a significant negative association between serum calcium levels and all the lipid profile except for HDL in cluster 1. Therefore, the negative loading of calcium with all the positive loading of lipid profile of the lipid + calcium cluster could have been explained. However, an epidemiological study in Belgian investigated the association between serum calcium and serum lipids from 5394 men and 4800 women and found a positive correlation between protein-corrected calcium and TC in both men and women, and a significant positive correlation between HDL and serum calcium levels in women (105). Thus, calcium has been shown to be related to TC both positively and negatively. More research is warranted on the relationships between serum calcium levels and lipid profile in individuals with and without MetS.

Insulin resistance cluster were positively associated with HOMA-IR, insulin and WHR. HOMA-IR was calculated by insulin and fasting glucose levels, so it was positively associated to insulin and contributed to the same factor. A study conducted in 1990 reported a higher insulin level and insulin resistance were correlated with higher WHR in obese post-menopausal women (106). Nutrition knowledge *per se* was not a predictor of MetS ; however, nutrition knowledge + vitamin D cluster was able to partially predict MetS, with MetS positively associated with fast food consumption and negatively associated with 1,25 D3 levels. Using factor scores from principal component analyses, it was observed that insulin resistance related cluster was the most important components in predicting MetS in overall oAAA, and also in oAAA girls and Young group. Nutrition knowledge + vitamin D cluster was also significantly associated with the oAAA Young group. The lipid profile + calcium factor was able to predict MetS in overall oAAA sample but not for oAAA girls and Young group. Future studies with larger sample size than the current one may be able to identify if any of the clusters can be used to predict MetS in boys or in older oAAA.

Based on the principle component and logistic regression model, reduced insulin resistance factors and HOMA-IR could be the most effective ways in reducing MetS in oAAA. For young oAAA, improving home food environment with more fruits and vegetables available, and increasing 1,25 D3 levels as well as reducing TC/HDL ratios could also reduce MetS. However, LDL negatively predicted the odds of MetS in Young group but was positively associated with lipid profile+ calcium cluster that increased the odds of MetS in overall sample. These results are conflicting. Serum LDL levels were significantly lower than the suggested high-risk levels in both oAAA with and without MetS in this study. Another study also suggested LDL particle size was a more important cardiovascular risk factor than the LDL levels (107).

Limitations

All the participants in this study were obese. Therefore results obtained from this study may not be applicable in adolescents with healthy body weight. There is the need to conduct a large-scale study in adolescents with a wide range of body weight to validate the results obtained from this study.

There were still concerns regarding the food frequency type of questionnaires used in disease related research (108), even though it is an commonly used tool for dietary data collection for large population studies and has been validated as a valuable tool for diversified populations. BFFQ provided estimates of the respondent's food intake patterns during the last 7 days and provided with a relative estimate instead of the actual dietary intake of previous day or days. However, the validity of the BFFQ has been conducted and compared with the 24hr food recall. No difference in the results were identified (109). Hence BFFQ was a valid tool and was used in this study to collect general food intake patterns in the oAAA. However, 24hr food recall might be a better tool for investigating the direct relationships of serum 1,25 D3 and calcium levels with the dietary intake of calcium and vitamin D.

The sample size was too small compared with other epidemiological studies and principal analysis and logistic analysis for oAAA boys and older group could not be conducted. There were only 9 oAAA boys that had no MetS and this number was smaller than the 14 variables tested. Therefore, logistic regression was not able to be performed. The sample size of older group was only half of the number in the young group and wasn't large enough to conduct a significant test in both statistical tests.

Conclusion

MetS rate was high in oAAA by using the IDF criteria and oAAA boys had higher MetS rate than oAAA girls. However, the MetS rates were similar in both Young and Older groups, indicating the MetS has appeared in very young adolescents. OAAA had high rate of all the risk factors. Among all of the risk factors, hyperglycemia and low HDL level contributed the most for defining MetS regardless of gender or age groups while high WC did not due to the fact that almost all the oAAA had high WC. Although no mean differences were found in serum leptin levels, fast food consumption, FEQ, FPQ, and dietary intake between oAAA with MetS and without MetS; serum calcium and 1,25 D3 were significantly lower in oAAA with MetS group. The insulin resistance related cluster was the most important predictor for MetS, while TC/HDL ratio, 1,25 D3, and food environment score separately predicted MetS in girls and young group oAAA. Further research to apply these models to a larger population to verify the findings in gender and age difference is urgently needed. Furthermore, the relationships between dietary and serum vitamin D and calcium need to be further examined especially in the population with MetS.

APPENDIX A

T1 T2 T3 T4 Date: _______________ ID#: __________

Fast Food Use and Sleep Quantity - Teen

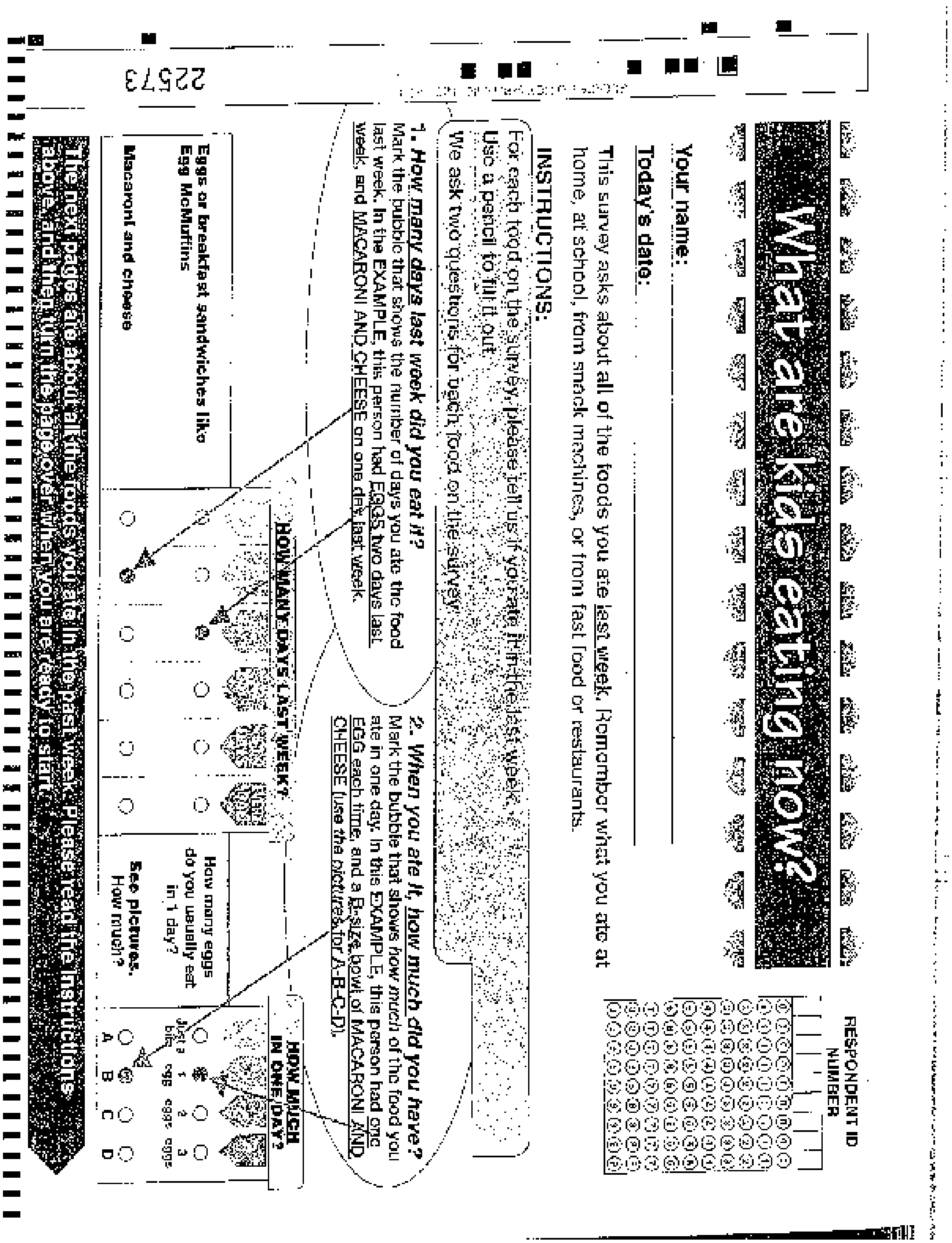
Fast Food Use

1. In the past week (_______ to _______), how many times did you eat something from a fast food restaurant (e.g., McDonald's, Burger King, Hardee's, Subway, etc)?

   ____

   a. Is this more, less, or the same as most weeks?
      i. More (1)
      ii. Less (2)
      iii. Same (3)

APPENDIX B


What are kids eating now?

RESPONDENT ID NUMBER

Your name:

Today's date:

This survey asks about **all** of the foods you ate **last week**. Remember what you ate at home, at school, from snack machines, or from fast food or restaurants.

INSTRUCTIONS:

For each food on the survey, please tell us if you ate it in the last week.
Use a pencil to fill it out.
We ask two questions for each food on the survey:

1. How many days last week did you eat it?
Mark the bubble that shows the number of days you ate the food last week. In the EXAMPLE, this person had EGGS two days last week, and MACARONI AND CHEESE on one day last week.

2. When you ate it, how much did you have?
Mark the bubble that shows how much of the food you ate in one day. In this EXAMPLE, this person had one EGG each time, and a B-size bowl of MACARONI AND CHEESE (use the pictures for A-B-C-D).

	HOW MANY DAYS LAST WEEK?		HOW MUCH IN ONE DAY?
Eggs or breakfast sandwiches like Egg McMuffins		How many eggs do you usually eat in 1 day?	Just a bite / 1 egg / 2 eggs / 3 eggs
Macaroni and cheese		**See pictures.** How much?	A / B / C / D

The next pages are about all the foods you ate in the past week. Please read the instructions above, and then turn the page over when you are ready to start.

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Think about every time you ate anything in the past week. You can tell us you didn't eat a food at all in the past week, or that you ate it one day last week, two days last week, 3-4 days, 5-6 days, or every day.

Page 2

Remember what you ate at **home**, at **school**, from **fast food**, or from a **restaurant**.

	HOW MANY DAYS LAST WEEK?							HOW MUCH IN ONE DAY?			
				DAYS	5-6 DAYS	EVERY DAY					
Pancakes, waffles, Pop Tarts	○	○	○	○	○	○	How many?	○ ½	○ 1	○ 2	○ 3
Granola bars, breakfast bars	○	○	○	○	○	○	How many?	○ ½	○ 1	○ 2	○ 3
Eggs or breakfast sandwiches like Egg McMuffins	○	○	○	○	○	○	How many eggs do you usually eat in 1 day?	○ Just a bite	○ 1 egg	○ 2 eggs	○ 3 eggs
Bacon or sausage	○	○	○	○	○	○					
Cooked cereal like oatmeal or grits	○	○	○	○	○	○	**See pictures.** Which bowl?		○ B	○ C	○ D
Cold cereal, like Corn Flakes, Frosted Flakes or any other kind	○	○	○	○	○	○	**See pictures.** Which bowl?		○ B	○ C	○ D
When you ate cereal, which kind did you eat? (MARK THE ONE YOU ATE THE MOST OF)	○ Sweet cereals like Frosted Flakes, Froot Loops ○ Plain cereals like Corn Flakes, Cheerios, Rice Krispies ○ Fiber cereals like Raisin Bran, Shredded Wheat ○ Fortified cereals like Total or Product 19										
How often do you have milk on cereal?	○	○	○	○	○	○					
Bananas	○	○	○	○	○	○	How many do you usually have in 1 day?	○ ½	○ 1	○ 2	○ 3
Apples or pears	○	○	○	○	○	○	How many do you usually have in 1 day?	○ ½	○ 1	○ 2	○ 3
Oranges or Tangerines (<u>Don't count juices</u>)	○	○	○	○	○	○	How many, in one day?	○ ½	○ 1	○ 2	○ 3
Strawberries or other berries	○	○	○	○	○	○	**See pictures.** How much?	○ A	○ B	○ C	○ D

Page 3

Remember what you ate at **home**, at **school**, from **fast food**, or from a **restaurant**.

	HOW MANY DAYS LAST WEEK?							HOW MUCH IN ONE DAY?			
						EVERY DAY					
Applesauce, fruit cocktail or pineapple slices	○	○	○	○	○	○	**See pictures.** Which bowl?		○ B	○ C	○ D
Any other fruit, like grapes, peaches, watermelon, cantaloupe, fruit roll-ups	○	○	○	○	○	○	**See pictures.** How much do you usually eat?	○ A	○ B	○ C	○ D
Hamburgers or cheeseburgers, at home or from a fast food restaurant	○	○	○	○	○	○	How much?	○ ½ small burger	○ 1 small burger	○ 1 large burger	○ 2 large burgers
Which kind do you usually eat?	○ hamburgers			○ cheeseburgers							
Tacos, burritos or enchiladas	○	○	○	○	○	○	How many?	○ ½	○ 1	○ 2	○ 3
Which kind of tacos, burritos, enchiladas do you usually eat?	○ with meat or chicken			○ without meat or chicken							
Hot Pockets, meat ball subs or Sloppy Joes	○	○	○	○	○	○					
Roast beef, or steak	○	○	○	○	○	○	How much?	○ A	○ B	○ C	○ D
Hamburger Helper, beef and noodles, beef stew, or any other beef dishes	○	○	○	○	○	○	How much?	○ A	○ B	○ C	○ D
Pork chops, ribs, or cooked ham	○	○	○	○	○	○	How much?	○ A	○ B	○ C	○ D
Fried chicken including chicken nuggets, from home or from a restaurant like KFC	○	○	○	○	○	○	How many pieces?	○ 1	○ 2 (or 6 nuggets)	○ 3	○ 4
Any other kind of chicken, like roasted chicken, chicken stew, Chicken Helper	○	○	○	○	○	○	How much?	○ A	○ B	○ C	○ D

Page 4

Remember what you ate at **home**, at **school**, from **fast food**, or from a **restaurant**.

	HOW MANY DAYS LAST WEEK?							HOW MUCH IN ONE DAY?
		DAY	2 DAYS	3-4 DAYS	5-6 DAYS	EVERY DAY		
Any kind of fish, like fish sandwich, fish sticks, shrimp or tuna	○	○	○	○	○	○	How much?	○ A ○ B ○ C ○ D
Spaghetti, ravioli or lasagna <u>with tomato sauce</u>?	○	○	○	○	○	○	How much?	○ A ○ B ○ C ○ D
Macaroni and cheese	○	○	○	○	○	○	How much?	○ A ○ B ○ C ○ D
Pizza or pizza pockets	○	○	○	○	○	○	How many slices?	○ ½ ○ 1 ○ 2 ○ 3
Hot dogs or corn dogs	○	○	○	○	○	○	How many?	○ ½ ○ 1 ○ 2 ○ 3
Lunch meat like boloney, chicken, sliced ham. Remember sandwiches and Lunchables	○	○	○	○	○	○	How many slices of lunch meat?	○ ½ ○ 1 ○ 2 ○ 3
Refried beans	○	○	○	○	○	○	How much?	○ A ○ B ○ C ○ D
Vegetable <u>soup</u>, vegetable beef <u>soup</u>, or tomato <u>soup</u>	○	○	○	○	○	○	See pictures. Which bowl?	○ B ○ C ○ D
Any other soup like chicken noodle, Cup-a-soup, ramen noodles, or menudo, posole	○	○	○	○	○	○	See pictures. Which bowl?	○ B ○ C ○ D
Biscuits or muffins	○	○	○	○	○	○	How many?	○ ½ ○ 1 ○ 2 ○ 3
<u>Whole wheat</u> bread or whole wheat rolls	○	○	○	○	○	○	How many slices in one day?	○ 1 ○ 2 ○ 3-4 ○ 5 or more
<u>White bread</u>, toast or rolls, including sandwiches or bagels	○	○	○	○	○	○	How many slices in one day?	○ 1 ○ 2 ○ 3-4 ○ 5 or more

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Page 5

Remember what you ate at **home**, at **school**, from **fast food**, or from a **restaurant**.

	HOW MANY DAYS LAST WEEK?							HOW MUCH IN ONE DAY?
		1 DAY	2 DAYS	3-4 DAYS	5-6 DAYS	EVERY DAY		
Tortillas	○	○	○	○	○	○	How many ?	○ 1 ○ 2 ○ 3-4 ○ 5 or more
Margarine or butter, like on bread or on pancakes or on potatoes	○	○	○	○	○	○	How many times each day ?	○ 1 ○ 2 ○ 3 ○ 4
Cheese. Remember cheese in sandwiches	○	○	○	○	○	○	How many slices of cheese each day?	○ ½ ○ 1 ○ 2 ○ 3
Mayonnaise or sandwich spread	○	○	○	○	○	○		
Peanut butter sandwich	○	○	○	○	○	○	How many on those days?	○ ½ ○ 1 ○ 2 ○ 3
Jelly or jam	○	○	○	○	○	○		
Sunflower seeds, peanuts or other nuts	○	○	○	○	○	○	How much in one day?	○ A ○ B ○ C ○ D
Salad with lettuce, green salad	○	○	○	○	○	○	**See pictures.** Which bowl?	○ B ○ C ○ D
Salad dressing	○	○	○	○	○	○		
Green beans, string beans or peas	○	○	○	○	○	○	**See pictures.** How much?	○ A ○ B ○ C ○ D
Pinto beans, black beans, chili with beans, or bean burritos	○	○	○	○	○	○	**See pictures.** How much?	○ A ○ B ○ C ○ D

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Remember what you ate at **home**, at **school**, from **fast food**, or from a **restaurant**.

	HOW MANY DAYS LAST WEEK?							HOW MUCH IN ONE DAY?			
						EVERY DAY					
Corn or corn on the cob	○	○	○	○	○	○	**See pictures.** How much?	○ A	○ B	○ C	○ D
Tomatoes including on salad	○	○	○	○	○	○	How much?	○ A little	○ ½ tomato	○ 1	○ 2
Greens like collards, mustard greens or spinach	○	○	○	○	○	○	**See pictures.** How much?	○ A	○ B	○ C	○ D
Broccoli	○	○	○	○	○	○	**See pictures.** How much?	○ A	○ B	○ C	○ D
Carrots, carrot sticks or cooked carrots	○	○	○	○	○	○	**See pictures.** How much?	○ A	○ B	○ C	○ D
Sweet potatoes, or sweet potato pie	○	○	○	○	○	○	**See pictures.** How much?	○ A	○ B	○ C	○ D
French fries, Tater Tots, hash browns or home fries	○	○	○	○	○	○	**See pictures.** How much?	○ A	○ B (McD Small)	○ C (McD Large)	○ D (McD Super)
Any other kind of potatoes, like mashed, baked or boiled	○	○	○	○	○	○	**See pictures.** How much?	○ A	○ B	○ C	○ D
<u>Any other</u> vegetables, like squash, cauliflower or green or red peppers	○	○	○	○	○	○	**See pictures.** How much?	○ A	○ B	○ C	○ D
Rice, including fried rice, Spanish rice, rice with beans	○	○	○	○	○	○	**See pictures.** How much?	○ A	○ B	○ C	○ D
Ketchup, salsa, or barbecue sauce	○	○	○	○	○	○					

Remember what you ate at home, at school, from snack machines, at the movies, or from fast food.

	HOW MANY DAYS LAST WEEK?							HOW MUCH IN ONE DAY?			
						EVERY DAY					
Snack chips like potato chips, tortilla chips, Doritos, popcorn, Bugles	○	○	○	○	○	○	How much in the whole day?	○ A	○ B	○ C	○ D
Crackers, including snack crackers like Cheez-its, Ritz Bits, Goldfish	○	○	○	○	○	○	How much in the whole day?	○ A	○ B	○ C	○ D
Nachos with cheese	○	○	○	○	○	○	How much?	○ A	○ B	○ C	○ D
Ice cream, ice cream bars or frozen yogurt	○	○	○	○	○	○	See pictures. Which bowl?		○ B	○ C	○ D
Cookies	○	○	○	○	○	○	How many cookies?	○ 1	○ 2-3	○ 4-5	○ 6+
Donuts	○	○	○	○	○	○	How many donuts?	○ ½	○ 1	○ 2	○ 3
Cake, cupcakes, Tasty Cake, Ho-Ho's, Twinkies	○	○	○	○	○	○	How many pieces?	○ ½	○ 1	○ 2	○ 3
Pie, fruit pie, fruit crisp, cobbler	○	○	○	○	○	○	How many pieces?	○ ½	○ 1	○ 2	○ 3
Chocolate candy, like candy bars, M&Ms, Reese's, Tootsie Roll	○	○	○	○	○	○	How many bars?	○ 1 small	○ 1 medium	○ 1 large	○ 2 large
Any other candy (not chocolate), like Skittles, Starburst, Lifesavers, gum	○	○	○	○	○	○	How many packages?	○ ¼	○ ½	○ 1	○ 2
Chocolate milk, hot chocolate or cocoa	○	○	○	○	○	○	How many glasses or cartons each day?	○ ½	○ 1	○ 2	○ 3
Milk (not chocolate). (Don't count milk on cereal)	○	○	○	○	○	○	How many glasses or cartons each day?	○ ½	○ 1	○ 2	○ 3

What kind of milk do you usually drink?
○ Whole milk ○ Non-fat milk ○ Soy milk ○ Reduced-fat (2%) milk ○ Lactaid milk ○ Rice milk ○ Low-fat (1%) milk ○ Don't know

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Remember what you ate at **home**, at **school**, from **soda machines**, at the **movies**, or from **fast food**.

	HOW MANY DAYS LAST WEEK?							HOW MUCH IN ONE DAY?			
				3-4 DAYS	5-6 DAYS	EVERY DAY					
Sodas like Coke, Dr. Pepper, 7-Up, Sprite, Sunkist, Orange Crush. (Don't count diet sodas)	○	○	○	○	○	○	How many bottles or cans in 1 day?	○ 1	○ 2	○ 3-4	○ 5+
What size soda do you usually drink?	○ 12 ounce can ○ 20 ounce bottle			○ more than 20 ounces							
Slurpees, snow cones, popsicles (not ice cream)	○	○	○	○	○	○					
Hawaiian Punch, Kool-Aid, Sunny Delight, Gatorade, ice tea, Snapple	○	○	○	○	○	○	How many glasses in 1 day?	○ 1	○ 2	○ 3	○ 4
Hi-C, Tang, Tampico, Mr. Juicy, Ssips punch	○	○	○	○	○	○	How many glasses or juice boxes?	○ 1	○ 2	○ 3	○ 4
Real orange juice (Don't count Sunkist or other orange sodas)	○	○	○	○	○	○	How many glasses or juice boxes?	○ 1	○ 2	○ 3	○ 4
Any other real fruit juices like apple juice or grape juice. (Remember juice boxes)	○	○	○	○	○	○	How many glasses or juice boxes?	○ 1	○ 2	○ 3	○ 4

In the past week, did you take any **vitamin pills**, like One-a-Day or Flintstones? ○ No ○ Yes

If yes, how many days last week? ○ 1-2 ○ 3-4 ○ 5-6 ○ 7

Are you ○ Male ○ Female

How old are you? ______

How tall are you? [ ] Feet [ ][ ] Inches

How much do you weigh? [ ][ ][ ] Pounds

Are you (Mark all that apply)

○ African American
○ White
○ Hispanic/Latino
○ Asian
○ American Indian, Alaska native
○ Other

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TODAY'S DATE MO.	DAY	YR.	AGE	WEIGHT pounds	HEIGHT ft. in.

NM252837-1 98

APPENDIX C

Food Picture Questionnaire: Please circle the letter that corresponds to the child's answer.
K = Knows the food name P = Partially knows food name T = Had to tell the food name

Food 1 vs.	Food 2	Identify	Preference	Frequency	Health
Hamburger	Fish	H: K P T	H F	H F	H F
		F: K P T			
Vegetables	Vegetables with butter	NB: K P T	NB B	NB B	NB B
		B: K P T			
Popcorn	Donuts	P: K P T	P D	P D	P D
		D: K P T			
Egg	Bacon	E: K P T	E B	E B	E B
		B: K P T			
5Pretzels	Potato Chips	PZ: K P T	PZ C	PZ C	PZ C
		C: K P T			
Fried Chicken	Baked/Grilled Chicken	F: K P T	F G	F G	F G
		G: K P T			
Cheetos	Cereal	CH: K P T	CH CE	CH CE	CH CE
		CE: K P T			
Fresh Fruits	Fruit Candy	FF: K P T	FF FC	FF FC	FF FC
		FC: K P T			
Hot Dog	Sandwich	H: K P T	H S	H S	H S
		S: K P T			
10Low Fat Milk	Soda Pop	M: K P T	M S	M S	M S
		S: K P T			
Baked Potato	French Fries	BP: K P T	BP FF	BP FF	BP FF
		FF: K P T			
Apple	Cookies	A: K P T	A C	A C	A C
		C: K P T			

Identity Question: What food is this?
Preference Question: Which one tastes better?
Frequency Question: Which one do you eat more often?
Health Question: Which one is a healthy food?

APPENDIX D

In home = The food can be in the kitchen, pantry, bedrooms, basement, garage, or other rooms
Teen can immediately eat it = Is the food in a package/container that the teen is able to open, and/or does it require preparation that the teen can do on her/his own? (Regardless of whether or what rules may be about your teen accessing food by himself/herself)

How much = *A little* (enough for up to 2 people to eat at a snack/meal), *Some* (enough for 3-8 people to eat at a snack/meal), *A lot* (more than a little or some)

FOOD	*In home?*	*Teen can immediately eat?*	*How much is there?*
1. chocolate or other candy (can include chocolate chips)	*Yes No*	*Yes No*	*A little Some A lot*
2. already made cakes, brownies, cookies, muffins (not English)	*Yes No*	*Yes No*	*A little Some A lot*
3. boxed mixes for cakes, brownies, cookies, muffins (not English)	*Yes No*	*No*	*A little Some A lot*
4. regular chips (e.g., potato chips, corn chips)	*Yes No*	*Yes No*	*A little Some A lot*
5. pretzels or baked (or other non-fried) chips	*Yes No*	*Yes No*	*A little Some A lot*
6. fruit roll-ups or other dried fruit (including raisins)	*Yes No*	*Yes No*	*A little Some A lot*
7. sweetened breakfast cereal **(≥ 7g sugar/serving)**	*Yes No*	*Yes No*	*A little Some A lot*
8. unsweetened breakfast cereal **(< 7g sugar/serving)**	*Yes No*	*Yes No*	*A little Some A lot*
9. Non-butter crackers (e.g., saltines, graham crackers, wheat crackers, rye crispbread, plain: matzo, melba, or toast rye wafers)	*Yes No*	*Yes No*	*A little Some A lot*
10. fresh bananas, oranges, pineapple, melons	*Yes No*	*Yes No*	*A little Some A lot*
11. fresh apples, grapes, celery, lettuce	*Yes No*	*Yes No*	*A little Some A lot*

12. potatoes, corn on the cob, whole tomato, frozen vegetables	*Yes* *No*	*Yes* *No*	*A little* *Some* *A lot*
13. "100% fruit juice"	*Yes* *No*	*Yes* *No*	*A little* *Some* *A lot*
14. juice (e.g., punch)	*Yes* *No*	*Yes* *No*	*A little* *Some* *A lot*
15. regular sodas	*Yes* *No*	*Yes* *No*	*A little* *Some* *A lot*
16. sports drinks (e.g., Gatorade)	*Yes* *No*	*Yes* *No*	*A little* *Some* *A lot*
17. regular (whole) or 2% milk	*Yes* *No*	*Yes* *No*	*A little* *Some* *A lot*
18. frozen or unprepared bacon, sausage, or other breakfast meat (not turkey or low-fat meat based)	*Yes* *No*	*No*	*A little* *Some* *A lot*
19. ice cream or other frozen desserts	*Yes* *No*	*Yes* *No*	*A little* *Some* *A lot*
20. non-fat cheese or yogurt	*Yes* *No*	*Yes* *No*	*A little* *Some* *A lot*
21. hot dogs or bologna (not turkey or low-fat meat based)	*Yes* *No*	*Yes* *No*	*A little* *Some* *A lot*
22. turkey, chicken, fish or other lean labeled meat	*Yes* *No*	*Yes* *No*	*A little* *Some* *A lot*

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ABSTRACT

METABOLIC SYNDROME IN OBESE AFRICAN AMERICAN ADOLESCENTS

by

YULYU YEH

August 2014

Advisor: Dr. K.L. Catherine Jen

Major: Nutrition and Food Science

Degree: Doctor of Philosophy

Limited research regarding the relationship of metabolic syndrome (MetS), serum calcium, vitamin D level, nutrition knowledge, and food environments (FE) has been conducted in obese African American adolescents (oAAA). MetS is a constellation of risk factors that increase the risk for chronic diseases and is defined as presence of any 3 or more of the 5 criteria: fasting glucose ≥100mg/dl, waist circumference >90th percentile, triglycerides ≥150 mg/dl, blood pressure (BP) ≥130/85 mmHg and HDL <40mg/dl. The aim of this study was to assess the incidence of MetS in oAAA and the relationship between MetS and, FE, serum calcium, leptin, and 1,25-dihydroxy vitamin D (1, 25D3) levels. Principle component analysis was used to cluster all the variables. One hundred and fifty one OAAA (mean age: 14.3 ± 1.4 years, 65.6% girls, mean BMI: 37.4±7.2 kg/m^2) took part in this study. Anthropometric data, fasting blood samples, and self -report questionnaires were collected. The MetS rate for OAAA was 61.6% and boys had higher MetS than girls (73.1%, 55.6% respectively). The lipid profile +calcium, insulin resistance, and nutrition knowledge + vitamin D clusters

increased the odds ratio (OD) of MetS. (OD=1.67, 2.29, and 1.65 respectively). Calcium and 1,25D3 levels were higher in the group without MetS and both had negative associated with the cluster. The insulin resistance cluster also increased the OD of MetS in girls and younger oAAA (OD=2.07 and 2.79 respectively). However, this was not observed in boys or older oAAA. There was also a negative association on HFE but this was only observed in younger age groups. OAAA was in high risk for having MetS. Insulin resistance cluster was the main risk factor that predicts the OD of MetS compared to clusters.

AUTOBIOGRAPHICAL STATEMENT

Yulyu Yeh is a PhD Candidate in the Nutrition and Food Science Department, Wayne State University, Detroit, MI. She is expected to graduate in August 2014 with a doctor of philosophy degree and a minor in Psychology. Miss Yeh graduated from Wayne State University with a MS in Nutrition and Food Science in 2010 and graduated from Chung Hsing University in Taiwan, in 2006 with a BS in Animal Science.

During her graduate studies, Yulyu worked as a research assistant at WSU.

She was a member of the research team in the “Head Start: healthy kids healthy live” program from 2008 to 2009. After that she was coordinator for the “Assessments of health status in preschoolers: A feasibility study” program from 2009 to 2010. And the she was also involved in the FIT family project which was also the project that she wrote her dissertation on.

Poster presentation in Conferences (latest 3):

- **Yeh Y**., Brogan K., Naar-King S., Tang J., Jen K-L C, Vitamin D and Calcium: The Relationship of Dietary Intakes and Blood Levels in Obese Minority Adolescents, presented in Experimental Biology, San Diego, CA, 2014.
- **Yeh Y**., Naar-King S., Brogan K., Jen K-L C. Elevated risk of type 2 diabetes and hyperlipidemia but not hypertension in urban obese African American adolescents, presented in The Obesity Society, Atlanta, GA, 2013.
- **Yeh Y**., Naar-King S., Brogan K., Jen K-L C. Prevalence of Metabolic Syndrome in Obese African American Adolescents and the Role of Fast Food Consumption, presented in The Obesity Society, San Antonio, TX, 2012