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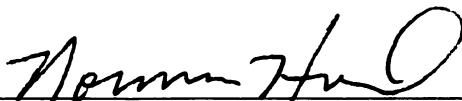
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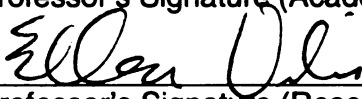
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**THE PREVALENCE AND CLUSTERING OF ELEVATED LEVELS OF
BIOMARKERS RELATED TO METABOLIC SYNDROME IN BOYS AND GIRLS
12-19 YEARS OLD USING NHANES III, 1988-1994**

By

Louise van Wyk

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ABSTRACT

THE PREVALENCE AND CLUSTERING OF ELEVATED LEVELS OF BIOMARKERS RELATED TO MS IN CHILDREN AND ADOLESCENTS 12-19 YEARS OLD, NHANES III (1988-1994)

By

Louise van Wyk

Metabolic Syndrome (MS) has been estimated to affect 4% of adolescents in the United States and is believed to be rising steadily due to the dramatic increase in overweight in adolescents. Currently there has been inadequate information reported on biomarkers associated with MS in children and adolescents, as well as a clear definition to understand and define MS in children and adolescents. The first two objectives of our study were to determine the distribution and prevalence of elevated levels of biomarkers associated with MS by age and by sexual maturation stage. The third objective was to examine the clustering of these biomarkers among boys and girls 12-19 years old (using factor analysis) and the association between demographic variables and identified clusters of biomarkers. Analyses were conducted using data from NHANES III (1988-1994). Our main findings were that the distribution and prevalence of elevated levels of biomarkers differed by age and by Tanner stage within gender, depending on the biomarker under study. Biomarkers that clustered together in boys and girls were waist circumference levels, triglyceride levels, BMI-for-age percentiles and decreased HDL-cholesterol levels. The factors obtained suggest that specific subsets of biomarkers associated with MS occur in adolescents. In addition, these data provide the first insight into the clustering of specific biomarkers related to MS in adolescents in a nationally representative sample.

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Chapter 1: Introduction

1.1 Overview:

Metabolic Syndrome (MS) has been estimated to affect 4% of adolescents in the United States (1) and is believed to be rising steadily due to the dramatic increase in overweight in adolescents (2). Until recently it was a condition found almost exclusively in adults. Results from a recent population-based study also concluded that 25% of the adult population in the US currently suffers from MS (3).

MS, otherwise known as Syndrome X and Insulin Resistance Syndrome, has been defined as a clustering of metabolic abnormalities, including resistance to insulin-stimulated glucose uptake, hyperglycemia, hyperinsulinemia, increased plasma concentration of very-low-density lipoprotein (VLDL) triglycerides, decreased concentration of high-density lipoprotein (HDL) cholesterol and hypertension (4). Other abnormalities associated with this syndrome include abnormal weight distribution (generally defined as visceral and central adiposity) and increased biomarkers of inflammation (e.g. C - reactive protein) (5). Prevalence rates of the above metabolic abnormalities related to this syndrome has been increasing markedly in recent years in adolescents (6-9), especially among the obese population (10-13). In addition, few studies have been conducted to examine the distribution of biomarkers associated with MS in children and adolescents, particularly in population-based studies (14, 15).

MS is characterized by the co-occurrence of obesity which by itself has been increasing dramatically in the United States (in particular, among adolescents), and has become a major public health concern among all age and race/ethnic groups (2, 16). In 2000 the prevalence of overweight (defined as BMI $\geq$ 95th percentile for age on the age-

and sex specific growth charts from the Centers for Disease Control (CDC)(17)) children (6-11 yr) in the United States was 15.3% and it was 15.5% for adolescents (12-19 years) and has been predicted to continue to increase (2).

MS has also been shown to predict type 2 diabetes (18), cardiovascular disease (CVD) (19) and could possibly be associated with increased risk for cancer (20). Type 2 diabetes also is emerging as a major public health concern, especially among adolescents, and seems to parallel the dramatic increase in obesity (21, 22). Until the early 1990's there was a low prevalence of less than 1% of type 2 diabetes in the US adolescent population (12-19 years old), but within the past decade there has been a rapid increase of 8-45% based on geographical location (23, 24) and socio-economic position (25). CVD has been shown to be one of the leading causes of mortality and morbidity in adults with MS (26) and findings from the Bogalusa Heart Study indicated that risk factors for CVD in children include overweight and obesity, hypertension, dyslipidemia, physical inactivity and a high-fat diet (27).

Intervention programs to prevent childhood obesity are necessary, since overweight during adolescence is also believed to be an important predictor of long-term morbidity and mortality (28, 29). Research suggests that it is more efficacious to implement intervention programs geared toward preventing overweight youth rather than overweight adults (30). Many studies have shown that overweight children are more likely to become overweight as an adult compared to normal weight children (31, 32) and one study concluded that among obese compared to non-obese children there was a four-fold increased risk of developing MS as an adult (33). The implementation of appropriate interventions in children and adolescents could potentially decrease elevated

levels of biomarkers related to MS and the development of MS, type 2 diabetes, cardiovascular disease and possibly cancer.

The etiology of MS is multifactorial where environmental factors as well as genetic factors are believed to act as interacting determinants. Lifestyle factors, such as physical inactivity and diet however, seem to be the most closely linked to MS (34-38). A randomized controlled clinical trial recently showed that both moderate and vigorous physical activity levels can decrease the risk for developing MS ((OR= 0.52 (95% CI: 0.40,0.67) for vigorous) and (OR=0.78 (95% CI: 0.63,0.96) for moderate)) in adults. This was significant after adjusting for all other confounding factors (34). The National Cholesterol Education Program also recommends weight loss and increased physical activity, as the basis of therapy for MS (39). However, more studies are needed to address the effect of diet and physical activity on MS especially in children and adolescents.

A recent study by Cook et al. defined MS in adolescents based on a predetermined definition of elevated levels of three or more biomarkers related to MS (1). Many studies however, have used a factor analysis approach to identify MS in adults (5, 40-43), and results among studies were all found to be consistent. To our knowledge, no studies have defined MS in adolescents using **factor analysis** in a nationally representative sample. This study will determine the prevalence and clustering of markers of Metabolic Syndrome in a nationally representative sample of children using factor analysis. This factor analysis approach will allow us to identify the potential clustering of biomarkers related to MS in adolescents and to then determine the relationship of participants with these clusterings to demographic characteristics, such as race/ethnicity and poverty income ratio, physical activity, television watching and

tobacco use. In chapter 2 below, we will also review the pathophysiological basis of MS and the relationship of MS to cardiovascular disease and type 2 diabetes mellitus.

1.2 Specific Aims for this Study are:

Aim 1: To examine the distribution and determine the prevalence of elevated levels of biomarkers related to Metabolic Syndrome in boys and girls 12-19 years **by age** within gender, race/ethnicity and poverty income ratio. Biomarkers to be examined will be: BMI-for-age Percentiles, Waist Circumference, Total Triglycerides, Total Serum Cholesterol, Serum HDL-Cholesterol, LDL-Cholesterol, Serum Glucose, Systolic Blood Pressure, Diastolic Blood Pressure and C - Reactive Protein (which will only be used to determine the prevalence of elevated levels (> 0.22 mg/dL)).

Aim 2: To examine the distribution and determine the prevalence of elevated levels of biomarkers related to Metabolic Syndrome in boys and girls 12-19 years **by sexual maturation stage** (pubic hair assessment) within gender, race/ethnicity and poverty income ratio. Biomarkers to be examined will be: BMI-for-age Percentiles, Waist Circumference, Total Triglycerides, Total Serum Cholesterol, Serum HDL-Cholesterol, LDL-Cholesterol, Serum Glucose, Systolic Blood Pressure, Diastolic Blood Pressure and C - Reactive Protein (which will only be used to determine the prevalence of elevated levels (> 0.22 mg/dL)).

Aim 3: To examine the **clustering of biomarkers** that have previously been associated with Metabolic Syndrome in adults, in boys and girls 12-19 years, using factor analysis, and the association between demographic variables and **identified factor scores**.

Variables to be included in factor analysis will be: BMI-for-age Percentiles, Waist Circumference, Total Serum Cholesterol, Total Triglycerides, Serum HDL-Cholesterol, LDL-Cholesterol, Systolic Blood Pressure, Diastolic Blood Pressure and Serum Glucose.

1.3 Rationale for Study Aims:

The goals of this study are to determine the distribution and prevalence of elevated levels of biomarkers associated with MS, as well as the clustering of these biomarkers among boys and girls 12-19 years old. We will also examine the association between demographic variables and identified clusters of biomarkers. To conduct these analyses we will use population-based data from the USA, using NHANES III (1988-1994).

To our knowledge only three studies have examined the distribution of biomarkers that are related to MS in children and adolescents (8, 14, 15). Furthermore, we are not aware of studies that have presented the distribution of biomarkers by focusing on MS, or examined the distribution by socio-economic status. One study examined the distribution of biomarkers related to MS (triglycerides, HDL-cholesterol, LDL-cholesterol and total cholesterol) by race/ethnic group (14). The distribution of biomarkers related to MS in our study will therefore be able to serve as a reference value for normal and high levels in adolescents since our data is representative of the general US population. In addition, there are very few studies that have looked at the distribution

of biomarkers related to MS with regard to pubertal stage of development (44-47).

Pubertal stage of development can possibly influence levels of biomarkers related to MS (48-50). For example a longitudinal study recently showed that early menarche is characterized with higher prevalence of clustering of adverse levels of biomarkers related to MS in young adulthood (48). To our knowledge no studies have examined the distribution of biomarkers related to MS by age. Since during this period in life, adolescents can have such fluctuating clinical values, and it is important to determine, at what age these elevated levels of biomarkers fluctuate the most so that we can stratify or adjust for age in our analyses.

In the analyses for Aim 1 and Aim 2 we will stratify by age and Tanner stage in order to determine the age distribution and Tanner stage distribution among each risk factor related to MS. Results from Aim 1 and Aim 2 will further allow us to decide whether we should stratify by age, or Tanner stage in Aim 3 when utilizing the factor analysis approach. If results from Aim 1 and Aim 2 do not vary substantially, then we will be able to combine boys and girls in our overall sample as well as stratify by gender in our analysis, which has more biological meaning.

Current prevalence rates of elevated levels of biomarkers related to MS were recently presented by Cook et al. in children and adolescents 12-19 years old using NHANES III (1). These researchers defined MS, based on an “a priori” approach and reported the prevalence of elevated levels of biomarkers in adolescents which are believed to be problematic (discussed in Chapter 2). They then defined MS on the basis of the definition in adults (39), as having three or more of the clinically problematic levels of biomarkers. Our analyses strategy will differ from theirs in that they did not

stratify by age or pubertal status when determining the prevalence of elevated levels of biomarkers related to MS.

In our analysis, we will make use of factor analysis to define MS in adolescents. This approach has been consistently used in adults and found to produce meaningful factors that represent the definition of MS as defined by the World Health Organization (WHO) (51) and the National Cholesterol Education Program (NCEP) (52). To our knowledge only one study has used factor analysis to define MS in children and adolescents and this study is not representative of the general population (53). The factor analysis procedure will enable us to identify a single unifying factor that represents the clustering of biomarkers based on empirical data, instead of restricting the emphasis to predetermined factors as done by Cook et al. (1). The criteria used to define Metabolic Syndrome in children and adolescents will differ some what from the criteria to be used in this study although overall similar cut-off points will be used. A recent study by Shen et al. presented a high-order common factor representing MS in adults by using factor analysis. Based on their results obtained the authors call for further studies in youth and minority groups (43)

Our ultimate goal of this study is to identify children and adolescents who are at risk to develop elevated biomarkers related to MS, since MS is known to be associated with obesity, type 2 diabetes and cardiovascular disease and also possibly cancer. By identifying adolescents at risk for MS can pose significant emphasis on prevention and intervention for future development of MS, type 2 diabetes, cardiovascular disease and cancer. These data from this work may help to identify unique features of clustering of biomarkers related to MS in children and adolescents not seen in adults experiencing this

syndrome. This will allow us to focus on intervention programs to control, if possible specific components of this syndrome in children and adolescents, through potentially physical activity and diet. Such early targeted interventions have the potential to decrease risk for the development of type 2 diabetes, cardiovascular disease and cancer, as well as MS.

Chapter 2: Background

2.1 Definition of Metabolic Syndrome

A report from the World Health Organization (WHO) described “metabolic syndrome” as a “major classification, diagnostic and therapeutic challenge” (51). Meigs et al., defined MS as the co-occurrence of multiple metabolic and physiologic risk factors for both type 2 diabetes mellitus and atherosclerotic cardiovascular disease”(5). A study by Bergstrom et al. , as well as many other studies, have hypothesized that the clustering of metabolic risk factors leads to impaired glucose tolerance, hyperglycemia, hyperinsulinemia, dyslipidemia, and sodium retention that result in MS, Syndrome X (54, 55). Other terms associated with MS are “deadly quartet”, “multiple Metabolic Syndrome” and “metabolic cardiovascular syndrome”(4, 56-61).

Reaven hypothesized that insulin resistance was the fundamental defect causing the metabolic abnormalities in this syndrome, and defined it as Insulin Resistance Syndrome (4). However, recent research has shown that resistance to insulin may not be the main cause of the syndrome (62). The World Health Organization (WHO) redefined this syndrome as MS (51). The prevalence, pathophysiology and appropriate treatment of MS have been widely studied in adults, but not as extensively in youth, given until recently it was only seen in adults. Clear definitions of MS have been established for adults, by The World Health Organization (WHO) (Table 2.1) (51) and the NCEP ATP III (Table 2.2)(39).

Table 2.1 Diagnosis of Metabolic Syndrome in Adults by World Health WHO* ⁽⁵¹⁾

Presence of insulin resistance or fasting hyperinsulinemia and 2 or more of:

- | | |
|--|---|
| - Hyperglycemia: | Fasting plasma glucose ≥ 6.1 mmol/l but nondiabetic |
| - Blood pressure: | $\geq 140/90$ mm Hg or treated for hypertension |
| - Total Triglycerides: | Men: ≥ 2.0 mmol/L and/or HDL-cholesterol < 1.0 mmol/L
Women: < 0.9 mmol/L |
| - Central obesity (waist circumference): | Men: ≥ 94 cm
Women: ≥ 80 cm
And or BMI ≥ 30 kg/m |
| - Microalbuminuria: | urinary albumin excretion rate > 20 mcg/min or albumin/creatinine ratio ≥ 30 mg/g. |

* WHO: World Health Organization; † HDL-C: High density lipoprotein cholesterol; hyperglycemia defined as: fasting plasma glucose ≥ 6.1 mmol/L or impaired fasting glucose in non-diabetic individuals.

Table 2.2 Diagnosis of Metabolic Syndrome in Adults by NCEP ATP III* ⁽³⁹⁾

Three or more of:

- | | |
|--|--|
| - Abdominal obesity Waist circumference: | Women: > 88 cm; Men > 102 cm |
| - Total Triglycerides: | ≥ 1.7 mM (150 mg/dL) |
| - HDL-C [†] : | Women: < 1.16 mM (50 mg/dL)
Men: < 0.91 mM (40 mg/dL) |
| - Blood pressure: | $\geq 130/85$ mmHg |
| - Fasting plasma glucose | ≥ 6.1 mM |

* Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults

"Male patients can develop MS when their WC is only marginally increased e.g. 94-102 cm. They may have a strong genetic contribution to IR and they will benefit from life habits, similarly to men with categorical increases in WC" (39)

Because these definitions of MS differ, the prevalence estimates reported in the literature for one population could differ from another population. Two studies compared the prevalence of MS using both definitions. A prospective study done in adults in Finland determined that the WHO definition was the most sensitive for predicting prevalent and incident cases, whereas the NCEP definition was less sensitive but had a

much higher specificity (37). They also found that adults who were diagnosed with the defined criteria for MS were also more likely and at a higher risk to develop type 2 diabetes, according to the NCEP definition and the WHO definition. The odds for developing type 2 diabetes over a 4 year follow-up ranged from 5.0-8.8 for both definitions (37). A study by Ford et al. using data from NHANES III showed that 23.9% of the participants had MS determined by the ATP III definition and 25.1% had the syndrome when classified according to the WHO definition (63). The two definitions were similar for non-Hispanic whites, but differed greatly by other race/ethnic groups. Therefore we can conclude that a more universally accepted definition is needed in order to accurately define a population as having MS. This next brings us to the pathogenesis and classification of biomarkers related to metabolic syndrome in order to better understand the mechanism so that a more clear definition can be established.

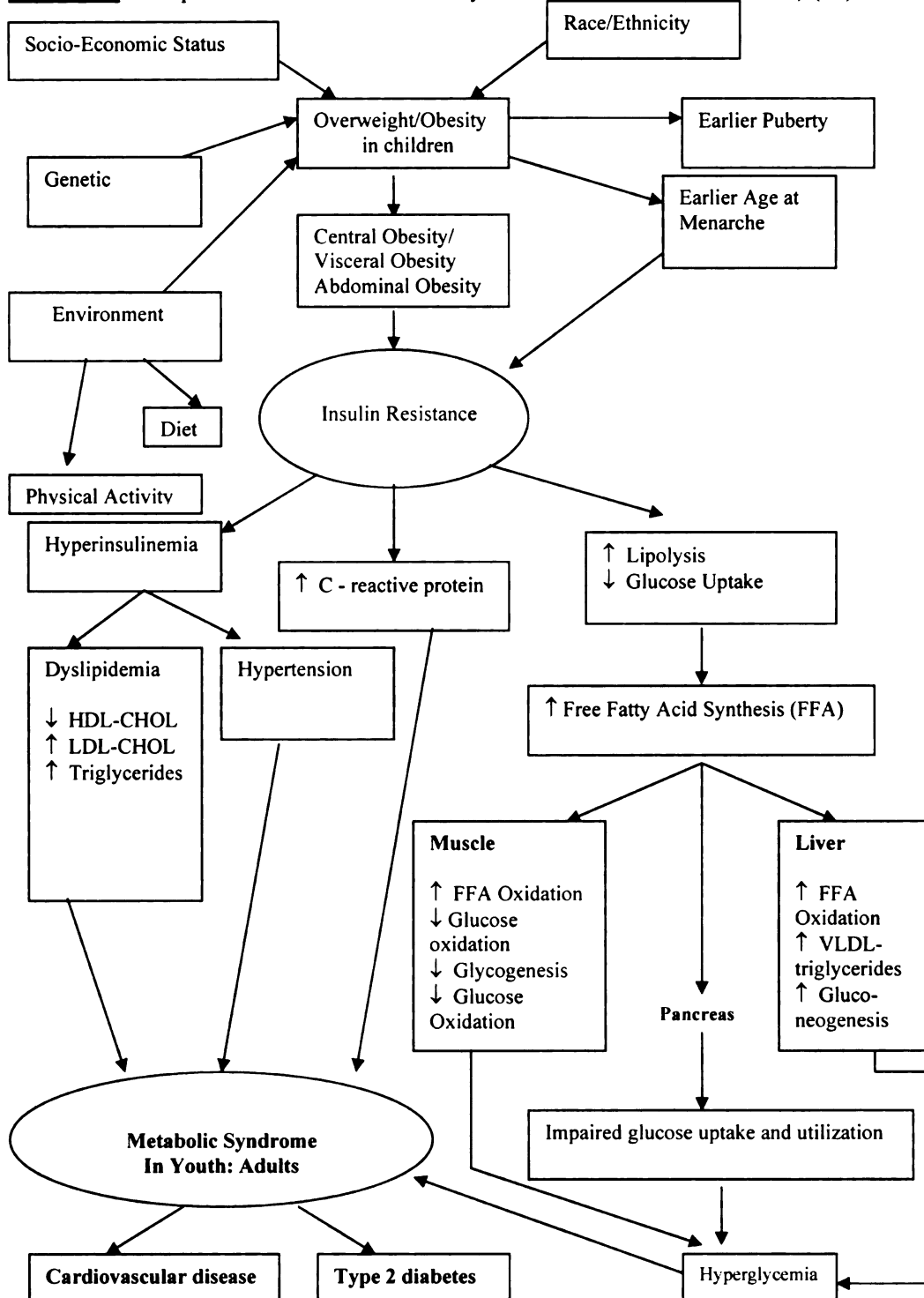
2.2 Pathogenesis and Classification of Metabolic Syndrome

The pathogenesis of this syndrome involves the clustering of risk factors, which are all associated with type 2 diabetes and cardiovascular disease (4, 59, 61). A few population studies in adults, such as the Framingham Offspring Study and Atherosclerosis Risk in Communities Study (AIRC) showed that the metabolic risk factors co-occur far more than by chance alone. In the Framingham study low HDL-cholesterol levels and elevated levels for BMI, systolic blood pressure, triglycerides, glucose and total cholesterol, clustered at twice the rate that was predicted by chance. The same results were found in the AIRC Study. In the Framingham Offspring Study,

they also showed that subjects with MS had a 11-fold increased risk for developing type 2 diabetes, and a 2.5-fold increased risk for developing CVD (64, 65).

We can therefore assume that the interrelated mechanisms among insulin resistance, elevated lipid levels, increased blood pressure and elevated glucose levels, indicates that MS risk factors work in synergy and come together to influence the etiology of chronic disease (cardiovascular disease, type 2 diabetes mellitus) (43) (See figure 2.1 below). We discussed each risk factor related to MS in detail to get a better understanding of the pathophysiology of this syndrome.

Figure 2.1 Proposed model of Metabolic Syndrome (Based on Timar et al.) (66)



2.2.1 Insulin Resistance and Hyperinsulinemia

Insulin Resistance, known as the main cause and a characteristic feature of MS (4) can be defined as a condition when physiologic concentrations of insulin are unable to accurately regulate proper glucose and lipid homeostasis (67). Above-mentioned procedures (glucose and lipid homeostasis) under normal insulin production conditions include reduced blood glucose concentrations, which involves gluconeogenesis and glycogenolysis, triglyceride synthesis in the liver and adipose tissues, increased breakdown of circulating lipoproteins and suppressed lipolysis (the breakdown of triglycerides into free fatty acids and glycerol) in both adipose tissue and in muscles (67). Insulin Resistance has also been defined as a common pathophysiologic state in which target cells fail to respond to ordinary levels of insulin, and therefore produce a subnormal biologic response (68). It has been hypothesized that the defects that occur during the insulin action could be related to the failure of insulin to suppress lipolysis (69).

Children and adolescents experience increased levels of insulin at specific stages in their lives. During puberty especially, sensitivity to insulin decreases significantly between Tanner stages 1 and 2 and then remains stable throughout stages 2, 3 and 4, and then increases at Tanner stage 5 (70). This idea has first been put forward by Amiel et al in 1986 (71). They concluded that insulin-stimulated glucose metabolism was about 30% lower in children at Tanner stage 2 and 4 compared to children in Tanner stage 1 and 5. Another study found that during Tanner stage 3, insulin sensitivity decrease almost 25-30%. This is also called “peak reduction”, whereas again sensitivity increases and stays gradually constant at Tanner stage 5 (72). In a longitudinal study, Goran concluded

that the reduction in insulin sensitivity occurs over a very brief period and is not due to body fat, because body fat varies tremendously during puberty and insulin sensitivity was similar among obese and non-obese children (70). It is known that prepuberty is a more insulin sensitive state compared to puberty, possibly due to the sensitivity of lipoprotein lipase to insulin during prepuberty, which then leads to increased triglyceride clearance from the circulation and increased triglyceride storage in adipose tissue (73). It has also been found that lipid oxidation increases during puberty, which is possibly regulated by increased growth hormone (GH) secretion, which can then be responsible for the decreased glucose disposal and insulin resistance (11, 74). This mechanism however is still not clearly understood.

Insulin resistance, as shown figure 2.1 is said to be one of the consequences of obesity. As an adult gains weight, the body becomes resistant to insulin and insulin sensitivity declines by 30-40%, especially when an individual gains weight 35-50% more than ideal bodyweight (59). Similar findings were seen in children since 1987 when Freedman et al. studied 355 black and white school children and found that there was a significant but weak association ($r=0.3-0.4$) between central body fat and fasting insulin (75). A study by Gutin et al. found a stronger correlation ($r=0.78$) between percentage body fat and insulin levels in 7-11 year old children (76). Sinaiko et al, also found that BMI was significantly correlated with fasting insulin and inversely correlated with insulin sensitivity in 714 children, $\pm$ 12-13 years old (77). In addition, various other studies have been performed to determine whether visceral adiposity or general adiposity is related to fasting insulin and insulin resistance. The majority of these studies found that visceral fat was significantly related to fasting insulin, and in contrast to the above

mentioned statement, that body fat in general seems to be the predominant factor on insulin sensitivity (78-80). This hypothesis is supported especially in the younger population.

BMI along with waist-hip-ratio (WHR) are the most reliable methods for assessing bodyweight among adults (81). Schmidt MI et al. showed that there is a very strong correlation between fasting insulin concentrations and body mass index (OR=1.6 to 4.5, $p<0.05$), and Karter et al. found that insulin sensitivity is inversely related to WHR, independent of BMI, in both gender groups and in all ethnic groups in the Insulin Resistance and Arteriosclerosis Study (IRAS) (82, 83). However, among children BMI is known to not be a very sensitive indicator of body composition, especially during puberty, because body composition changes dramatically during puberty (73). Insulin resistance is also known to affect lipid metabolism and glucose metabolism as shown in figure 2 (84). Ronnema et al. showed that serum insulin correlated positively with serum triglycerides and inversely with HDL-cholesterol in young children within the highest insulin quartile (85). Furthermore, resistance to insulin as well as hyperinsulinemia are characteristics of both type 2 diabetes and impaired glucose tolerance (86).

2.2.2 Dyslipidemia

Dyslipidemia is characterized by a so-called “lipid triad”: increased triglycerides (Tg), decreased high-density lipoprotein cholesterol (HDL-cholesterol) and elevated low-density lipoprotein cholesterol (LDL-cholesterol) (66). It is well known in the literature that elevated levels of above-mentioned lipids and lipoproteins in the bloodstream are

associated with increased risk of atherosclerosis, including coronary heart disease and that most of the pathological processes and risk factors has its onset during childhood (22).

High serum levels of total cholesterol, especially associated with LDL-cholesterol are linked to increased coronary risk. With regards to LDL-cholesterol, it is the size and the density of the particle which is correlated with increased coronary heart disease risk. The smaller and denser the particle, the easier the particle will oxidize and will cause the particle to be transported at a slower rate, therefore being more atherogenic (66). Elevated triglycerides also are associated with increased coronary risk, and are mainly found in very low density lipoprotein cholesterol (VLDL-cholesterol). VLDL-cholesterol is responsible for transporting triglycerides in the plasma (87). There is a strong link between VLDL-cholesterol and HDL-cholesterol, in the sense that HDL-cholesterol concentrations are usually low when triglyceride (VLDL-cholesterol) concentrations are high (87). HDL has been termed the “memory box” of triglycerides and can also be used as a long-term indicator of disturbances in triglycerides (87). An inverse association exists between HDL-cholesterol and coronary heart disease risk (87). HDL-cholesterol is also known to be lowered by people with an atherogenic lifestyle, including smoking, obesity and physical inactivity (87).

Findings from the Bogalusa Heart Study suggests that as the number of cardiovascular risk factors increase, the pathological evidence increases for developing atherosclerosis in early childhood (88). These results also suggested that almost all children 2-15 years old have aortic fatty streaks, and another 50% of children 2-15 years old have fatty streaks in their coronary vessels, of whom 8% of those have raised fibrous

plaque. This strongly supports the link to the development of dyslipidemia and hypertension in children (88).

Lipid levels in adolescents have been shown to differ by race/ethnic group. Investigators from the Bogalusa Heart Study found that African Americans have greater concentrations of serum total cholesterol and HDL-cholesterol, and lower concentrations of triglycerides and VLDL-cholesterol than whites, and have a greater deposition of fat in the central region than whites (89). Another study by Hickman et al. supported the above findings in that non-Hispanic black children had higher mean total cholesterol, LDL-cholesterol and HDL-cholesterol levels compared to non-Hispanic whites and Mexican American children (14). Webber et al. also concluded that clustering of multiple cardiovascular risk factors occurred greatest among white boys and African Americans girls (90).

Bodyweight itself may be a significant predictor of elevated lipid levels in adolescents. Since 1979, the Bogalusa Heart Study has showed that there is a significant correlation between cholesterol and body weight for 13-14 year old boys and 11-12 year old girls (90). The Bogalusa Heart Study further reported negative associations between central adiposity and disturbances in lipid and lipoprotein concentrations, particularly triglycerides and HDL-concentrations (91). Percent body fat is therefore associated with an atherogenic lipid profile, as reflected by higher levels of LDL during prepuberty, and higher levels of total cholesterol and LDL-cholesterol during puberty. A study found that overweight children (defined as BMI > 85th percentile for age and gender) were 2.4 times as likely as normal weight children to have an elevated level of total cholesterol. They were also more likely to have higher levels of diastolic blood pressure (OR=2.4), LDL-

cholesterol (OR=3.0), HDL-cholesterol (OR=3.4), systolic blood pressure (OR=4.5), triglycerides (OR=7.1) and fasting insulin (OR=12.6) (9).

Washington (92) reported that elevated levels of plasma insulin are common in adults and are frequently associated with coronary heart disease. In an earlier study Haffner et al. provided evidence that hypertriglyceridemia and low HDL- cholesterol concentrations are closely related with insulin concentrations. Their findings were independent of age, gender, ethnicity, body mass index and centrality in middle-aged adults (61). Various studies in both children and adults have shown that hyperinsulinemia is associated with an adverse pattern of cardiovascular risk factors that include obesity, dyslipidemia and hypertension. De Fronzo et al. summarized evidence from various studies that suggest that resistance to insulin and hyperinsulinemia causes increased synthesis of VLDL particles (Very-low density lipoprotein) and this leads to an increased production of plasma triglycerides accompanied by insulin resistance (59). This abnormality occurred in normal weight healthy subjects, obese subjects as well as in NIDDM subjects. Insulin resistance that occurs during dyslipidemia is thought to be due to the overproduction of VLDL particles which occurs when free fatty acids (FFA) and glucose from the liver increase as well as through the inhibition of Apo B degradation and decreased lipoprotein lipase levels (93). Hyperinsulinemia is also shown to be associated with a decrease in HDL-cholesterol levels (59). This mechanism is complex and involves the major lipoprotein in HDL-cholesterol, apolipoprotein I. There is an inverse relationship between apoAI/HDL degradation, which exceeds and enhanced rate of apoAI/HDL synthesis (59). Sinaiko et al. on the other hand found that fasting insulin was significantly correlated with systolic blood pressure in boys and girls, and all lipids

($p < 0.0001$) except high-density lipoprotein-cholesterol (HDL-Cholesterol) in boys and triglycerides and HDL-cholesterol in girls. But after adjustment for BMI, fasting insulin became significantly related to triglycerides (77).

Therefore we conclude that elevated levels of risk factors related to cardiovascular disease can have its onset early in childhood and will persist into adulthood leading to major health problems and contribute to the development of MS.

2.2.3 Blood Pressure

Dietz et al. has reported that overall hypertension in children does not occur very often (94). In a study of 6622 children 8 to 15 years old in Muscatine, Iowa, only 1% had persistent elevated blood pressure (Blood pressure $> 95^{\text{th}}$ percentile for age and sex or 140 mm Hg systolic or 90 mm Hg diastolic) (95). Children classified as having constant elevated blood pressure were also found to be obese with relative weights in excess of 120% (95). It is important to note that blood pressure during childhood varies widely throughout the day in children and in adults, because of normal diurnal fluctuation and changes in physical activity, emotional stress and other factors (96).

The Second National Heart, Lung and Blood Institute Task force developed definitions for high blood pressure/hypertension in children and adolescents (96). Normal blood pressure is defined as systolic and diastolic blood pressure being less than the 90^{th} percentile for age and sex and height. High-normal blood pressure is defined as average systolic or diastolic blood pressure greater than or equal to the 90^{th} percentile but less than the 95^{th} percentile for age, sex and height. Hypertension is defined as the average systolic or diastolic blood pressure greater than or equal to the 95^{th} percentile for

age, sex and height measured on at least three separate occasions (96). Age, race, sexual maturation stage, height and body mass index (BMI) has all been found to be significant predictors of elevated blood pressure levels in longitudinal analyses (97). In addition, investigators concluded that both systolic and diastolic blood pressures increased with age in black and white girls of similar ages (97, 98).

Sexual maturation stage is found to be an independent predictor of elevated blood pressure (98). Black girls had higher blood pressure levels than white girls at each maturation stage, and were also found to mature earlier than white girls. Blood pressure is also found to increase with height and BMI in children and adolescents. Even after adjustment for age, race and height, sexual maturation still remained related to blood pressure (97). After adjustment for age, weight, height and BMI, the racial differences remained significant for systolic blood pressure only, but not for diastolic blood pressure (97). A study conducted by the National Center for Health Statistics (NCHS) concluded that children who maintained higher blood pressure than their peers were significantly taller, heavier had greater bone age and had an earlier sexual maturation. They were also more likely to be obese, as indicated by skinfold thickness, hip and waist circumferences and body weight indices (98, 99). Other studies also concluded that body size was found to be one of the most important determinants of BP in childhood and adolescence (96, 98). From the above evidence, it is therefore important to identify precursors and markers of hypertension and elevated blood pressure especially in youth.

In adults, hypertension has been found to occur frequently in diabetic individuals, as well as in individuals with cardiovascular disease. Hypertension in adults has been shown to be associated with components of MS, which includes insulin resistance,

hyperinsulinemia, glucose intolerance and dyslipidemia (60, 100). Insulin resistance and hyperinsulinemia has been found to play a causal role in the development of hypertension in adults (59). In addition, insulin has been shown to be a predictor of incident hypertension independent of BMI, waist-hip-ratio, weight change and baseline blood pressure (101). In children, fasting insulin and the acute insulin response were positively related to systolic blood pressure, but not diastolic blood pressure, and insulin sensitivity ($p < 0.001$) was negatively associated with systolic and diastolic blood pressure, after adjustment for body composition (102). One study however, conducted in adults, did not find insulin resistance to be associated with hypertension (103).

The mechanism through which insulin works in its relationship with hypertension is complex. Insulin acts as a potent vasodilator, and studies have shown that insulin-mediated vasodilation is impaired in insulin-resistant states (104, 105). Insulin has been shown to be responsible for elevation in blood pressure via: Na retention; CNS activation; enhanced fluxes of Na and Ca into vascular smooth muscle cells, which will lead to increased vascular sensitivity to the vasoconstrictor effect of pressor amines, and the proliferation of arteriolar smooth muscle cells (59). Therefore, the causality behind the association between insulin resistance and hypertension is still a matter of great controversy, but we can conclude that essential hypertension, just like obesity and NIDDM, is an insulin-resistant state. However, studies in adults have shown that weight loss and physical training can improve the body's sensitivity to insulin, and effectively lowers blood pressure (106, 107).

2.2.4 C-reactive Protein

C-reactive protein (CRP), an acute phase protein produced by the liver can be described as a sensitive marker for systemic inflammation (108). Recent studies have suggested that low-grade systemic inflammation may play a role in the pathophysiology of MS (109-111). CRP have been shown to be significantly associated with a variety of cardiovascular risk factors in adult men (Physicians Health Study), including systolic and diastolic blood pressure, exercise, plasma lipids (Total-cholesterol, triglycerides), homocysteine, smoking, age and BMI (112). Pannacciulli et al. studied healthy adult women and found that factors such as age, insulin resistance, central fat accumulation and the amount of total body fat were the most powerful predictors of CRP concentrations (113). Another study using data from NHANES III (1988-1994) found that the prevalence of increased CRP levels was higher in both overweight and obese adults compared to normal weight adults (114). The same results were seen when studying children 8-16 years old from a nationally representative sample (NHANES III). They found that 7.1% of the boys and 6.1% of the girls had elevated levels of CRP and overweight children were more likely to have elevated CRP levels than normal-weight children (115). They also found that the odds ratio for having elevated CRP levels was 3.74 for overweight boys and 3.17 for overweight girls, based on BMI (115).

Studies have suggested that the elevated CRP concentrations might be due to elevated cytokine Interleukine-6 (IL-6) in adipose tissue (108, 116, 117). This is because increased levels of IL-6 from adipose tissue may induce elevated CRP levels in people with excess body fat. Recent studies also found that increased levels of CRP correlate positively with waist circumference and visceral adipose tissue (which will be discussed

below) in adults (118-120). Elevated levels of CRP observed in obesity, type 2 diabetes mellitus, hypertension, CHD and insulin resistance are all critical components of MS and suggests that the low-grade systemic inflammation plays a significant role in these conditions (110). We can therefore conclude that inflammation plays an important role in the development of MS and the diseases that are associated with it.

2.2.5 Impaired Glucose Tolerance

Impaired glucose tolerance (IGT) is defined as a glycemic response to the standard 75-g oral glucose challenge that is intermediate between normal and diabetic ranges (121). In adults it has been shown that people with impaired glucose tolerance are at a higher risk to develop type 2 diabetes mellitus (38). Timar et al. suggests that both the etiology of non-insulin dependent diabetes mellitus and impaired glucose tolerance occurs due to the independent development of impaired pancreatic beta-cell function as well as insulin resistance. Once the beta-cells from the pancreas fail to maintain the high rate of insulin secretion and at the same time fail to compensate for insulin resistance, impaired glucose tolerance occurs, followed by diabetes. Prior to this stage the pancreas is still able to enhance its secretion of insulin appropriately to compensate for the onset of insulin resistance, and glucose tolerance still remains normal (66). Therefore once the loss of blood glucose tolerance begins to emerge, glucose intolerance has its onset. During the past decade an increase frequency in the occurrence of type 2 diabetes mellitus has been reported in adolescents of all race/ethnic groups (122). Diagnosis of type 2 diabetes in children occurs usually only after the age of 10 years, due to the physiological insulin resistance that occurs during puberty (22). The pathophysiology

however is complex and multifactorial, and parental history plays a big role in the development of type 2 diabetes.

There are two important anthropometric characteristics which indicate the risk for MS in children and can be detected in the early stages of development during childhood. Therefore a review of body fat distribution and waist circumference is discussed.

2.2.6 Body Fat Distribution and Waist Circumference

Due to the rapid increase in overweight and obesity especially in childhood, it is important to understand the relationship between body fat distribution and components of body composition with disease in order to prevent further complications later in life. The presence of excess fat in the abdomen is shown to be an independent predictor of health related diseases (e.g. type 2 diabetes, cardiovascular disease) in adults and waist circumference is highly correlated with abdominal fat content. It has been shown that in adults, visceral adipose tissue tends to be more highly correlated with MS markers than subcutaneous abdominal adipose tissue (123-125). Visceral adipose tissue, not BMI or waist-hip-ratio has been shown to be significantly correlated with elevated triglycerides, low high-density lipoprotein and elevated insulin levels in obese girls (91).

In adults, waist circumference has been shown to be highly correlated with plasma lipids, lipoproteins and insulin levels, as well as visceral adipose tissue (126). Furthermore in children, waist circumference has been found to be highly correlated with high levels of plasma lipids and lipoprotein levels (127, 128). Freedman et al. found that in the Bogalusa Heart Study these associations existed independently of weight, height, and age. The results were also found to be similar among race and ethnic groups (128).

Waist circumference can also be used as an index of both fat distribution and generalized obesity. A few studies also supported the fact that waist circumference can be used as a predictor of risk factors for MS/Cardiovascular disease in children (129-131). Savva et al. reported that both waist circumference and waist-to-height ratio were better predictors of cardiovascular risk factors than BMI. BMI seemed to be a good predictor for high systolic and diastolic blood pressures (131). Results from stepwise multiple regression analysis found that waist circumference was a significant predictor for all risk factors related to cardiovascular disease, except for triglyceride levels in girls (131).

Morena et al. utilized Receiver Operating Characteristic (ROC) curves to predict MS from waist circumference measurements. A ROC curve is a way of evaluating the accuracy of a diagnostic test by summarizing the potential of the test to discriminate between the absence and presence of a disease i.e. the ability of waist circumference to identify children with MS. They found that the highest area under the curve corresponded to waist circumference (0.868) compared to BMI (0.849) and triceps/subscapular skinfolds (0.834), but this was not statistically significant (130). Waist circumference has also been found to be a predictor of early pubertal development. One study found that girls with higher average waist circumference across ages 7 and 9 years (OR= 1.11) as well as girls who show a linear increase in waist circumference through 7 and 9 years (OR=1.12) were more likely to reach puberty and to mature earlier than at 9 years (132).

From the above-mentioned literature we can conclude that waist circumference seems to be an appropriate, measurement technique to use in children, and relatively easy to acquire. As mentioned before, MS is known to occur mainly in adults, therefore the

prevalence of MS in adults will be discussed to emphasize again the importance and rationale of determining the prevalence in youth.

2.3 Prevalence of Metabolic Syndrome in Adults

According to the National Cholesterol Education Program (NCEP) ATP III guidelines the prevalence of MS was still unknown until recently (39). Timar et al. described MS as a multifaceted syndrome, which occurs mainly in adults > 50 years old, and the syndrome is also more common in men than in women (66). Ford determined the prevalence of MS in USA adults (≥ 20 years), by using data from the Third National Health and Nutrition Examination Survey (NHANES III) (3). The NCEP ATP III criteria were used to assess the prevalence of MS. Findings from this study were that overall the unadjusted and age-adjusted prevalence's of MS was 21% and 23% respectively. A similar study done on the same population and used the same diagnostic criteria showed similar overall prevalence statistics (133). Results showed that MS was present in 4.6%, 22.4% and 59.6% of normal-weight, overweight and obese men, and similar results were found for women (133). The study by Ford et al. showed that the prevalence of MS increases with age, i.e. for ages 20-29 the prevalence was 6.7%, 60-69 years, 43.5% and 42% for participants 70 or older Table 2.3 – Exact values for in-between years are not available).

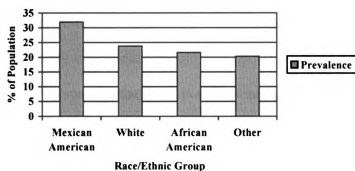
Table 2.3 Prevalence of Metabolic Syndrome according to NCEP ATP III criteria among US adults[#] age 20 years and older. (stratified by age)* (3)

Age in years	Prevalence (%)
20-29	6.7
60-69	43.5
70 >	42

* Exact values for in between years (30-59) were not available in the article; # Data from NHANES III

The increase in MS with age could be due the simultaneous increase in obesity in the population, or the fact that insulin sensitivity may decrease with age. Prevalence rates did not differ much among men and women, but rates were higher for Mexican Americans (31.9%) and lowest among non-Hispanic whites (23.8%), African Americans (21.6%) and people reporting an “other race” or ethnicity (20.3%) (Figure 2.2) (3). Park et al. reported significant differences between Mexican American and non-Hispanic white men, compared to non-Hispanic black men ($p < 0.001$ and $p < 0.006$). The latter mentioned had a much smaller prevalence than the former (13.9% compared to 20.8% and 24.3%). For women there was no significant relationship between non-Hispanic white and non-Hispanic black women (22.9% and 20.9%) but Mexican American women had a significantly higher prevalence (27.2%) (133). The effect of ethnicity and MS could be due to Mexican Americans adapting to a more westernized lifestyle and lack of activity. However, this could also be due to genetics. Age-adjusted prevalence rates also showed that Mexican-American men and women had significantly higher rates for MS compared to non-Hispanic white and non-Hispanic black men and women (133).

Figure 2.2 Age-adjusted prevalence of Metabolic Syndrome in adults 20 years and older by race/ethnic group : NHANES III, 1988-1991(3)



Higher body mass index (BMI), current smoking, low household income, high carbohydrate intake, no alcohol consumption and physical inactivity were also associated with increased odds of having MS (133). It was concluded that age-specific prevalence rates to US census counts from 2000, that 47 million US residents currently suffer from MS, (3) and Park et al. concluded that approximately one fourth of US adults 20 years or older meet the diagnostic criteria for MS (133). The numbers mentioned above are likely to underestimate the current prevalence of MS due to the increasing rise in obesity and its adverse metabolic effects in the US over the last decade (3). It is now clear the MS is a big health concern in adults, and only recently with the focus on childhood obesity and type 2 diabetes, children became a concern as well. However, during growth, both boys and girls experience puberty and girls experience menarche as well. This all can play a big role in when and how MS occur, and in our study we will determine the effects of puberty in girls and boys on biomarkers related to MS. Therefore I would like to discuss current knowledge of when does puberty and age and menarche occur in the general population.

2.4 Adolescence and Puberty

According to Marshall and Tanner, puberty can be defined as that time of life when morphological and physiological changes occur in the growing child (134). Adolescence on the other hand is defined as a period of physical and psychological development from the onset of puberty to maturity (135). It is during adolescence in which lifetime habits and behaviors are established that will likely be maintained into

adulthood (136-138). The majority of studies reporting the development of secondary sexual characteristics have made use of the five stages of development defined by Tanner et al. (139). Stage 1 is considered as pre-pubertal and stage 5 as post-pubertal. All 5 stages describe the growth of pubic hair in boys and girls, breast development in girls and genital development in boys. Table 2.4 describes pubertal stages 1 to 5 for boys and girls, according to breast development, pubic hair development and genital development (140).

Table 2.4 Description of pubertal stage as defined by breast, genital and pubic hair development (140)

	Breast	Pubic Hair	Genital
Stage 1	Pre-adolescent; elevation of papilla only	Pre-adolescent; the vellus over the pubes is not further developed than that over the anterior abdominal wall	Pre-adolescent; Testes, scrotum and penis are about same size and shape as in early childhood
Stage 2	Breast bud stage; elevation of the breast and the papilla as a small mound. Areolar diameter is enlarged over stage 1 (Preadolescent)	Sparse growth of long, slightly pigmented downy hair, straight, or slightly curled, chiefly at the base of the penis or along the labia	Scrotum and testes are slightly enlarged. Skin of scrotum is reddened and changed in texture. Little or no enlargement
Stage 3	Breast and areola are both enlarged and elevated more than in stage 2. No separation of their contours	Hair is considerably darker, coarser and more curdled. Spreads sparsely over the junction of the pubes	Penis is slightly enlarged at first mainly in length. Testes and scrotum are further enlarged than in stage 2
Stage 4	Areola and papilla form a secondary mound projecting above the contour of the breast	Hair is now adult type, but area covered is still smaller than in adult. No spread to medial surface of the thighs	(Lower Left) Penis is further enlarged, with growth in breadth and development of glans. Testes and scrotum are further enlarged than in stage 3. Scrotal skin is darker than in earlier stages
Stage 5	Mature Stage; Papilla only projects with areola recessed to general contour of breast	Hair is adult in quantity and type with distribution of the horizontal pattern. Spread is to medial surface of the thighs, but not up to linea alba or elsewhere above the base of the inverse triangle	(Lower right) Genitalia are adult in size and shape

2.5 Pubertal Development in Girls and Boys

One of the first studies to report age of onset and sequence of pubertal events was done by Marshall and Tanner in 1969. They reported that breast and pubic hair development in girls occurred almost simultaneously. The mean age for transition from breast stage 1 to 2 was 11.15 years and for pubic hair, it was 11.69 years. In contrast the mean age for onset of menarche was 13.47 years (141). Among boys, genitalia stage began to develop between the ages of 9.5 and 13.5 years, and Tanner stage 5 was reached between 13 and 17. In contrast to girls, genitalia development in boys has its onset before pubic hair development (142, 143). At approximately 16.5 years, most US girls and boys were sexually mature, i.e. they have reached all 5 stages of Tanner assessment. The median age at onset of pubic hair development for girls was 9.4 years for non-Hispanic blacks, 10.6 years for non-Hispanic white girls and approximately 10.4 years for Mexican American girls (143). Non-Hispanic black girls reached full maturity of pubic hair development at 14.7 years. Whereas non-Hispanic black girls and non-Hispanic white girls reached full maturity at approximately 16.3 years. The median age for the onset of breast development was approximately 9.5 years for non-Hispanic black girls, 9.8 for Mexican American girls, and 10.4 years for non-Hispanic white girls. Full breast development (classified as Tanner stage 5) was reached at approximately 14.0 years for non-Hispanic black girls, 14.7 years for Mexican American girls and 15.5 years for non-Hispanic white girls. For boys the median age for the onset of pubic hair development was approximately 11.2 years for non-Hispanic black boys, and 12.0 years and 12.3 years for non-Hispanic white and Mexican American boys. All boys reached full maturity (Tanner stage 5) for pubic hair stage at approximately 15.5 years. In the

same study, they also found that the median age for onset of genital development was approximately 9.2 years for non-Hispanic black boys, 10.0 and 10.3 years for non-Hispanic white and Mexican American boys. Full genital development for boys was approximately 15 years for non-Hispanic blacks, 16.0 for non-Hispanic whites and approximately 15.7 years for Mexican Americans (143).

Herman-Giddens' results were similar to the findings mentioned above for boys. They concluded that the mean age of pubic hair development for non-Hispanic white, African-American and Mexican American boys was 12, 11.2 and 12.3, and full maturity for pubic hair was reached at 15.7, 15.4 and 15.8 years. The mean age for full development of genitalia was 15.5 years for non-Hispanic-white, Mexican American and African American boys (144). It is therefore clear that maturation occurs significantly earlier in non-Hispanic black girls and boys compared to non-Hispanic white and Mexican American girls and boys.

2.6 Age at Menarche in Girls

Given that age at menarche occurs relatively later on in the pubertal process, this cannot be used as an indicator from which age of pubertal onset can be derived (145). Age at menarche is often influenced by various factors such as genetic parameters, race and ethnicity, socioeconomic conditions, physical activity and nutritional status (146, 147). According to various studies, age at menarche has changed little over the past few decades. Most studies have found that the mean age at menarche is between the ranges of 12 to 13 years old. A meta-analysis was done studying 67 countries worldwide. They found that the mean age at menarche among all countries was 13.53 years ($SD \pm 0.98$)

(147). Chumlea et al. studied age at menarche on a nationally representative sample, NHANES III (148). The median age at menarche for all races among US girls was 12.43 years. Non-Hispanic black girls (12.25 years) were more likely to have an earlier age at menarche than non-Hispanic white girls (12.55 years), and Mexican Americans were in the middle of the two. Median ages were recorded because ages were recorded as an integer, and it is therefore not possible to calculate the mean ages (148). Similar results were found in a cross-sectional/longitudinal study of non-Hispanic black and non-Hispanic white girls. They concluded that non-Hispanic black girls were more likely reach age at menarche 3 months earlier compared to non-Hispanic white girls (12.3 vs. 12.6 years) (149).

As mentioned above, age at menarche can be influenced and affected by many other factors. Many studies have examined and supported the association between age at menarche and adiposity (150, 151). A recent study by Freedman et al. studied black and white girls in the Bogalusa Heart Study. Their findings were significant in that women of both race/ethnic groups who reported an age at menarche before 12 years had a higher body weight and skinfold thickness compared to women who reported having age at menarche after 13.5 years. A limitation for this study however, was that age at menarche was self-reported. This again emphasizes that overweight and obesity in the US adolescent population is becoming a major health problem, since body fat and earlier age at menarche both lead to increased risk for several disorders (type 2 diabetes, cardiovascular disease) later in life. Recently, some further research was done by Frontini et al., who used the same group of women as mentioned above in the study by Freedman et al. They however, examined the longitudinal changes in adiposity and risk factors

related to MS in white and black girls in the Bogalusa Heart Study, and their relationship to early onset of menarche. They concluded in their results that girls who experienced menarche at an earlier age (less than 12 years) had higher insulin levels and lower decreases in glucose levels from childhood to adulthood. They also concluded that the prevalence of multiple risk factors related to MS in adults were higher (1.8-fold) in women with an earlier age at menarche (48).

Further population studies are needed to examine the relationship between age at menarche and risk factors related to MS. Pubertal development is therefore a critical period in life, and it is therefore important to clearly establish a definition for MS in youth, so that high risk children can be identified during pubertal development or even sooner. The current prevalence of MS in children and adolescents is warranted.

2.7 Prevalence of Metabolic Syndrome in Children

There is a paucity of studies that have estimated the occurrence of MS in children and to our knowledge only one study has described the prevalence of biomarkers associated with MS in a nationally representative sample in youth (1). A Swedish study (n=1032) concluded that features typical of MS, including elevated serum levels of insulin, TG, LDL-C, BP values and low HDL-C were already present in adolescents (14 year old and 17 year old) in the upper BMI quartile, compared to adolescents in the lower BMI quartile (55). The Bogalusa Heart Study used factor analysis to characterize the clustering of risk variables related to MS independent of sex and age. They defined the presence of MS in youth as having high blood pressure, dyslipidemia (high TG, and decreased HDL-C), hyperinsulinemia, and obesity. Seven risk variables (Ponderal index

(weight (kg)/height (m)³), insulin, glucose, triglycerides, and high density lipoprotein cholesterol, and systolic and diastolic blood pressure were reduced to two independent factors, which explained 50-59 percent of the variance in the total sample (53). A limitation however was that they did not define the prevalence of MS in children based on the known adult definition. Instead they defined the population in the top 25% of each quartile as having MS.

Cook et al. (1) recently estimated the prevalence and distribution of MS in adolescents using data from a nationally representative sample of the US population. They defined MS as shown in Table 2.5.

Table 2.5 Criteria for Metabolic Syndrome in children (1)

Criterion	Adolescents
High Triglyceride (mg/dL)	≥ 110
Low HDL-C (mg/dL)	
Males	≤40
Females	≤40
Abdominal Obesity, Waist circumference (cm)*	
Males	≥ 90 th Percentile
Females	≥ 90 th Percentile
High fasting glucose (mg/dL)	≥ 110
High blood pressure (mmHg) [†]	≥ 90 th Percentile

* Waist Circumference: All participants at or above the 90th percentile for age and sex; † Systolic and Diastolic BP: At or above the 90th percentile for age, sex, and height

The prevalence of MS as defined above in adolescents 12 -19 years old was 4.2%. The syndrome was more common in males (6.1%) than in females (2.1%) and also more common in Mexican Americans (5.6%) compared to non-Hispanic Whites (4.8%) and non-Hispanic Blacks (2.0%). They also stratified the subjects on BMI, and found that 28% of overweight adolescents met the criteria for MS. This study also examined the

prevalence of MS within Tanner stage, but did not find any significant differences. Rates did however increase among Tanner stage 2 (7.0% (0.0-15.4)) and 3 (7.2% (2.5-11.9)) and decreased again among Tanner stage 4 (3.5% (0.7-6.3)) and 5 (3.4% (1.5-5.4)) (1). This could possibly be due to the increase in insulin resistance experienced at certain ages during pubertal development, which will be discussed later in the literature review. The paucity of detailed studies of the characteristics of children at risk for experiencing characteristics of MS suggests more work needs to be done in this area. Therefore, our study will contribute to current knowledge known about Metabolic Syndrome in children, and results from this study will contribute to the need for screening and intervention programs in the general population.

Chapter 3: Methodology

3.1 Study Design and Population

This is a cross-sectional, descriptive study of the prevalence and clustering of biomarkers associated with Metabolic Syndrome (MS) among boys and girls 12-19 years old in the general U.S. population from 1988-1994. Data for this study came from the National Health and Nutrition Examination Survey (NHANES III), conducted by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC). This study was carried out in 50 states and the District of Columbia of the United States in two sets of phases, 1988-1991 and 1991-1994.

3.2 NHANES III Design and Data Collection Procedures

NHANES III is based on a complex, stratified multi-stage sample design conducted both in-home and in mobile examination centers (MEC)(152). Sampling was conducted in three stages. To begin with, the United States was divided into a number of primary sampling units (PSU's), which were each equivalent to a county (153). A total sample of 81 PSU's were selected and in some PSU's one or more counties was combined to assure a minimum sample size. The PSU's were all selected with probability proportional to size (i.e. depending on the size of the county), and 13 counties were all selected with a probability of one (e.g. California was selected as an individual PSU because of its size). The 13 counties were then divided into 21 survey locations. The remaining PSU's (68) were then grouped into 34 strata (two PSU's per stratum). Therefore the sample consisted of 89 survey locations (81 PSU's) that were randomly divided into 2 sets or phases of equal length and sample size. To prevent unbiased

estimates from developing, one set was allocated to the first three-year period (1988-1991) and the second set to the other three year period (1991-1994) (154). The second stage of sampling involved identifying “secondary sample units”, which included city or suburban blocks or combinations of blocks. The last stage involved selecting actual households as well as certain types of group quarters (dormitories). A subsample was selected from the households for screening and to identify eligible participants. Participants were selected into the study based on their age, sex, and race or ethnicity. Older persons, children, Mexican Americans and Black persons were oversampled to ensure that estimates of the health and nutrition status of the general U.S population could be accurately estimated (152).

In NHANES III, 39, 695 persons were selected over the six years as described above; of those, 33, 994 (86%) were interviewed in their homes, and the rest were classified as non-respondents (14%) (152). Approximately 30, 818 (78%) of the interviewed persons were also examined in NHANES III Mobile Examination Centers (MEC) and an additional 493 persons were given a special limited examination in their homes if they were not able to make it to the MEC (152). Data was collected in NHANES separately for children up to 16 years old and, for adults from 17 + years (152)

Data collection began with a household interview, followed by a physical examination and questionnaires in the MEC. During the household interview the following questionnaires were administered (questions asked during the household questionnaire were administered to a proxy corresponded for children younger than 17 years): Household Screener Questionnaire, Family Questionnaire, Household Adult Questionnaire, and Household Youth Questionnaire. During the examination at the MEC,

five automated questionnaires or interviews were administered: The MEC Adult Questionnaire, The MEC Youth Questionnaire, The MEC Proxy Questionnaire, a 24-hour Dietary Recall, and a Dietary Food Frequency Questionnaire. Only data from the Household interview and MEC examination were used in this study.

The health examination at the MEC included a variety of tests and procedures. The examinee's age at the time of the interview and other factors determined which procedures were administered at the MEC. Subjects (12 years and older) were instructed to fast for 10-16 hours prior to the morning examination or for six hours before the afternoon or evening examination. Blood and urine specimens were obtained, and a number of tests and measurements were performed on these biologic samples. A physician also performed a limited standardized medical examination. Based on the age of the sample person, the components included body measurements, blood pressure, spirometry, venipuncture, physical function evaluation and a questionnaire to inquire about infant feeding, selected health conditions, cognitive function, tobacco use, and reproduction (154). Analyses in this study however, will include only adolescents 12-19 years old who fasted for 6 hours or more before their health examination.

3.3 Measurement of Biomarkers associated with Metabolic Syndrome

Of the data collected in NHANES III, the following were used in this study: anthropometric measurements (BMI percentiles, waist circumference), biochemical measures (serum lipids (total cholesterol, HDL-cholesterol, LDL-cholesterol, triglycerides), c-reactive protein, serum glucose, glycated hemoglobin levels, sexual development stages and blood pressure measurements (diastolic blood pressure, systolic

blood pressure) (154). A description of the collection procedures for these measures follows.

3.3.1 Anthropometric Measurements

Anthropometric measurements used in this study were waist circumference and BMI-for-age percentiles obtained from CDC. Measurements were taken in the MEC and trained examiners were responsible for recording of the body measurements of participants. In general, *standard procedures* as defined by NHANES III were followed for the anthropometric measurements. Height was measured in an upright position with a stadiometer, and weight was measured at a standing position using a self-zeroing scale (Mettler-Toledo, Inc, Columbus, Ohio). Height and weight was then used to calculate the BMI-for-age percentiles developed by CDC. The BMI-for-age growth charts are developed to screen for nutritional risk in children and are based on data from five national representative surveys (NHES III, NHES III, NHANES I, NHANES II and NHANES III), as well as some other supplemental surveys (United Vital Statistics, State of Wisconsin Vital Statistics, State of Missouri Vital Statistics, Fels Longitudinal Study and Pediatric Nutrition Surveillance System). BMI-for-age percentiles of participants in our study were calculated based on these growth charts and using a SAS program provided by CDC (17). The waist circumference measurement was made at the midpoint between the bottom of the rib cage and above the top of the iliac crest. Measurements of waist circumference were made for each subject at minimal respiration to the nearest 0.1cm (154).

3.3.2 Biomarkers

Biomarkers used in this study were serum total cholesterol, serum HDL-cholesterol, serum LDL-cholesterol, serum triglycerides, serum C - reactive protein, serum glucose and blood pressure. At the start of the examination in the MEC, a questionnaire was administered to determine the eligibility of the participant to have a blood measurement (venipuncture) taken as well as other measurements to be done in the MEC. The questions included were, whether it was safe to perform the venipuncture and to document and determine fasting compliance of the participant (154). Discussed below are the technique/measurements used to obtain each marker included for study in these analyses.

3.3.2.1 Lipids

Serum cholesterol, serum triglycerides and serum HDL-cholesterol was measured with a Hitachi 704 Analyzer (Boehringer Mannheim Diagnostics, Indianapolis, IN) in participants 12-19 years old (154). Cholesterol and triglycerides (hydrolyzed to produce glycerol) were measured enzymatically at the same time. Measurements of total and HDL-cholesterol and fasting triglyceride levels allows low-density lipoprotein (LDL) cholesterol levels to be calculated using the equation developed by Friedewald, Levy, and Fredrickson (154):

$$\text{LDL-cholesterol} = (\text{total chol}) - (\text{HDL chol}) - \text{Triglycerides}/5$$

LDL-cholesterol was calculated only in subjects with triglyceride values less than <400mg/dL, because as triglyceride levels increase, the proportion of cholesterol to triglycerides in VLDL-cholesterol decreases, which can lead to overestimation of VLDL-

cholesterol and underestimation of LDL-cholesterol, therefore causing errors (155). To assess accuracy of measurements, CDC prepared quality control pools (one for normal concentrations and one for elevated concentrations) and assigned reference values for each pool for total cholesterol, HDL-cholesterol and triglycerides. For cholesterol measurements, a coefficient of variation (CV) of $\leq 3\%$ was allowed. Accuracy of triglyceride measurements was determined with standardization criteria developed by CDC (e.g. if the concentration was between 89-176 mg/dL a maximum bias of ± 10 and a maximum standard deviation of 10 was allowed). A similar approach was used for HDL-cholesterol (e.g. a concentration of < 40 mg/dL was allowed a $\pm 10\%$ variation from the reference value and a standard deviation of 2.5) (154).

3.3.2.2 Serum Glucose

Serum glucose concentration was measured with Hitachi Model 737 multichannel analyzer (Boehringer Mannheim, Indianapolis, IN) in participants 12 years and older as part of a standard sequence of biochemical assessments (154). In analyzing glucose measurements, two types of quality control systems were used: 1) sample quality control and 2) batch quality control. The sample quality control was allowed a 5% coefficient of variation between-assays and within-assays. The batch quality controls were placed in the calibration rack at the beginning and at the end of the rack of the entire measurement run (154).

3.3.2.3 C-Reactive Protein

C-Reactive Protein was quantified in the Immunology laboratory, Department of Medicine, University of Washington, by latex-enhanced nephelometry using a modification of the Behring latex enhanced c-reactive protein assay on the Behring Nephelometer Analyzer System (BNA) (Behring Diagnostics, Westwood, Massachusetts) (154). Two types of quality control measures were used to determine the accuracy of the measurements. The assay could detect a minimal concentration of 0.21 mg/dL, and values below this level were classified as undetectable. A majority of individuals had values at the minimal detectable concentration, and therefore we categorized C - reactive protein as a categorical variable (grouped as ≤ 0.22 mg/dL as normal and > 0.22 mg/dL as elevated) to determine the prevalence estimates in the population (154). C-reactive protein was not used in analyses for Aim 3 due to the continuous distribution that it represents.

3.3.2.4 Blood Pressure and Blood Pressure Percentiles

Three blood pressure measurements were taken in the MEC by a trained physician using a standard procedure described below (154). The first, fourth, and fifth Korotkoff sounds (K1, K4, and K5) were recorded for those 5-19 years of age. The equipment used included a baumanometer, blood pressure cuffs, and a Littman-Classic Stethoscope. In measuring blood pressure the maximum inflation level was determined and three blood pressure readings were obtained. The participant was requested to be seated at the table in a relaxed but not slouchy position, with feet flat on the floor. The right arm of the participant was placed on the table, and slightly flexed with palm upward. The arm was

supported at heart level; the cuff was applied with bottom edge one inch above crease in elbow. The blood pressure equipment was positioned so that the tube of the manometer was away from the participant's body while the inflation bulb was closer to the body (154).

Blood pressure percentiles were calculated based on each individual's age, gender and height simultaneously. The method to calculate the blood pressure percentiles was obtained from the normative blood pressure percentiles determined from nine studies in the USA (156). They had a total sample of 56, 103 children and adolescents (1-17 years old) for systolic blood pressure and 41, 335 children and adolescents (1-17 years old) for diastolic blood pressure of all race and ethnic groups. These percentiles calculated by Rosner et al., therefore represent the age-gender-height-specific percentiles for an "average study" over the nine studies that played a role. They however, only presented the 90th and the 95th systolic and diastolic blood pressure percentiles for children 1-17 years old in their paper. In this study we calculated all the percentiles for adolescents (12-19 years old). This was done by calculating the mean normal blood pressure from the regression coefficients provided by Rosner et al. (156) which came from the 9 studies that he used in his analysis for each height (height was entered as z-scores into the regression equations). We then calculated the z- scores of the blood pressure in our sample subtracted from the mean blood pressure of the nine studies, divided by the standard deviation, which was also provided by Rosner et al. (156). We then converted the z-score to percentiles with PROBNORM in SAS. To take into account the 18-19 year old kids in our analyses, we based the 18-19 year old children's blood pressure on the 17

year old children's blood pressure, since we didn't find big differences in the mean blood pressure levels between 18-19 year old adolescents and 17 year old adolescents.

Fasting Blood Biomarkers

This study includes children and adolescents 12-19 years old who fasted for 6 hours or more. In preliminary analyses done we chose only children who fasted for 9 hours or more, since that has been shown to be more biologically plausible in terms of the results obtained from a previous study (157). However, we compared clinical measurements on children who fasted for 6 to 9 hours with children who fasted for 9 hours or more and the results were found to be similar in both (Table 3.1)

Table 3.1 Comparison of clinical measurements between adolescents (12-19 years old) who fasted for 6-9 hours and adolescents who fasted for 9 hours or more: NHANES III, 1988-1994

Biomarker	Fasted for 6-9 hours			Fasted for 9 hours or more		
	N	Missing	Mean	N	Missing	Mean
BMI-for-age Percentiles	651	8	59.52	1642	24	61.92
Waist circumference (cm)	642	17	76.50	1626	40	77.90
Triglycerides (mg/dL)	626	33	88.20	1578	88	86.04
Total cholesterol (mg/dL)	628	31	164.73	1580	86	163.90
LDL-cholesterol (mg/dL)	624	35	95.63	1562	104	96.21
HDL-cholesterol (mg/dL)	624	35	51.33	1569	97	50.62
Serum glucose (mg/dL)	625	34	87.79	1538	128	87.95
C-reactive protein (mg/dL)	627	32	0.28	1556	110	0.31
Systolic Blood Pressure Percentile	639	20	39.93	1602	64	36.41
Diastolic Blood Pressure Percentile	608	51	34.88	1537	129	35.58

3.4 Covariates

3.4.1 Chronological Age, Sexual Maturation Assessment and Age at Menarche

This study includes children and adolescents age 12-19 of age. Age was calculated using the birth date obtained from the Screener Questionnaire (152).

Questions on sexual maturity of the subjects were assessed by trained physicians during the physical examination that took place in the MEC (154). Tanner sexual maturity stages were based on the recommendations of Tanner (141, 142). Tanner stage of pubic hair development, genitalia development in boys and breast development in girls was assessed for each subject by a trained physician. Tanner stages range from 1 to 5 where stage 1 represents immaturity, and stage 5 indicates full maturity (154). Age at Menarche was also obtained when administering the MEC Proxy Questionnaire. Data were collected on age of menarche for girls 8-19 years of age (154).

3.4.2 Race/Ethnicity

Race and ethnicity was based on self-report and were categorized as non-Hispanic White, non-Hispanic Black, Mexican American and Other race/ethnic participants. Questions asked to adolescents 12-16 were answered by a proxy correspondent. During the household interview, when administering the family questionnaire, a participant was provided with a hand card and then asked the following question: “Are any of those groups -----’s national origin or ancestry?” The choices on the card were 1) Mexican/ Mexican American and 2) Other Latin American or Other Spanish – please specify. The next question asked “What is the number of the group that best represents -----’s race?” And the options on the card were 1) Aleut, Eskimo, or American Indian, 2) Asian or Pacific Islander, 3) Black, 4) White, and 5) Another group not listed – specify” (152).

3.4.3 Poverty Income Ratio (PIR)

The Poverty Income Ratio used is based on measures developed by the US Bureau of the Census (154). The PIR was computed as a ratio of two components. The numerator was the midpoint of the observed self reported family income category in the Family Questionnaire. The denominator was the U.S poverty threshold (produced annually by the Census Bureau and adjusted for changes caused by inflation), the age of the family reference person, and the calendar year in which the family was interviewed(154). Persons who reported having had no income were assigned a zero value for PIR. There were a substantial proportion (10%, n=223) of participants in our study who refused to report their income (154).

3.4.4 Physical Activity Assessment (Adolescents 17-19 years old)

Physical activity was assessed during the Household Adult Questionnaire, which contained questions on usual leisure time physical activity in the past month (152). All participants were asked if they walked 1 mile or more at a time without stopping or if they jogged or ran, rode a bicycle, swam, participated in aerobics or aerobic dance, other dancing, callisthenic or floor exercise, gardening or yard work, or lifted weights during the past month. Participants were asked how many times they performed the exercise activity, and based on the type of activity, the metabolic equivalent (MET) intensity level(defined as a ratio of activity of metabolic rate: resting metabolic rate), was then assigned by NHANES III staff for each reported activity (152). We then classified

participant's usual physical activity level based on a recent review by Ainsworth et al (158) as light (< 3 MET's), Moderate (3-6 MET's) and Vigorous (> 6 MET's).

3.4.5 Television Viewing (Children 12-16 years old)

Assessment of hours of television watched the previous day was obtained from the adolescents when administering the Youth Questionnaire during the MEC visit (154). The question that was asked of 12-16 years old was: "How many hours of TV did you watch yesterday?" Television viewing was categorized into watching television for 1 hour or less, 2-3 hours, 4-5 hours and 5 hours or more per day (154).

3.4.6 Smoking Status

Assessment of smoking status was determined by questions asked on tobacco use to youth ages 8-16 in the MEC during the Youth Questionnaire and older adolescents 17-19 during the Household Questionnaire (154). Both questionnaires contained questions on the use of cigarettes and smokeless tobacco (snuff or chewing tobacco)(152). Self reported smoking was determined by collapsing variables on both questionnaires that were asked regarding current tobacco use. A participant was classified as a tobacco user when he/she reported that he/she was currently smoking cigarettes, cigars or pipes, or if he/she snuffed tobacco.

Biochemical determination of tobacco exposure was also performed by measuring serum cotinine levels in blood specimens obtained by venipuncture in the MEC (154). These cotinine levels were used to confirm tobacco use because sometimes people are not truthful when they answer questions about their smoking behavior. The cotinine assay

involved isotope dilution, liquid chromatography and tandem mass spectrometry. We used cutoff points of higher than 15ng/mL and 15ng/mL or less of cotinine in serum to designate active tobacco users and non-tobacco users. Previous studies using NHANES data used these cut-off points and have demonstrated a 96% concordance between self reported smoking status and serum cotinine levels (159, 160)

Smoking status was then categorized into three groups: Smoker, Non-Smoker and Possibly Smoker (See Table 3.2).

Table 3.2 Two-by-two table of smoking status and cotinine levels

Self Reported Smoking	Cotinine Levels					
	Missing		> 15 ng/mL		≤ 15 ng/mL	
	N*	% (of US population)	N*	%(of US population)	N*	% (of US population)
Yes	11	0.64	173	11.74	36	1.44
No	142	56.62	73	3.73	1888	76.84

* N of the sample in the study population

If a participant had cotinine levels > 15 ng/mL and self-reported smoking was yes then the participant was classified as a smoker. If a participant reported smoking and cotinine levels were less than 15 mg/dL then he/she was classified as smoking, because he/she might just not have smoked that day, and cotinine only has an in vivo half life of 24 hours which is still better than the in vivo half life of nicotine which is about 30 minutes (161). If a participant reported no smoking and cotinine levels were > 15ng/mL then that was grouped as possibly smoking. If a participant had missing cotinine levels and reported smoking then he/she was classified as smoking, and if a participant had missing cotinine levels and reported a non-smoker then he/she was grouped as a non-smoker. Finally, if a participant reported no smoking and cotinine levels were classified as ≤ 15mg/dL, then he/she was grouped as a non-smoker.

3.5 Analytic Sample and Characteristics

The original adult file (17 years +) consisted of 20050 people, and the original youth file (2 months to 16 years) had 13994 children (see table 3). The present study included only 17-19 year old adolescents (n=1225) from the adult file and adolescents 12-16 years old from the youth file (n=2216). Participants were then excluded from the study if they used drugs such as adrenal corticosteroids, estrogen/progestins, blood glucose regulators, thyroid/antithyroid drugs, oral contraceptives, or if they had any disorders of growth hormone secretion, pregnant girls, and girls who were pregnant in the last 2 years, participants with diabetes mellitus without mention of complication and cystic fibrosis. These exclusions were made because these conditions or drugs may affect the biomarkers related to MS.

Participants were considered eligible if they completed both the household questionnaire and the examination which took place in the MEC (see table 3.3). Therefore, 222 participants (7% of eligible participants) were excluded because they did not have information from both assessments. Furthermore, only participants who fasted for 6 hours or more (23% of participants were missing and not included) were included in these analyses to ensure stable estimates, which brought the total sample size to 2323 participants for analyses in Aim 1. Aim 2 included participants who also had information on sexual maturation assessment available, which included only pubic hair assessments. The total sample for Aim 2 thus includes 2062 participants who also fasted for 6 hours or more (11% were missing from the sample who fasted for 6 hours or more). The final sample, which is used to analyze aim 3, included 1931 participants who had complete

data on all variables under study (17% were missing from participants who fasted for 6 hours or more).

Table 3.3 Analytic Sample of Adolescents (12-19 years) in NHANES III

Status and reason for exclusion	N	% of total sample	N (Total) Sample
Adult File (17 years +)	20050		
Adult File (17-19)	1225		
Youth File (2 mnths – 16 years)	13944		
Youth File (12-16)	2216		
Adolescents eligible for study before exclusion			3441
Excluded Participants:			
Adrenal Corticosteroids	24		
Estrogen/Progestins	61		
Blood Glucose Regulators	23		
Thyroid/Antithyroid	3		
Contraceptives	52		
Disorders of Growth Hormone Secretion	0		
Pregnant now/Pregnant during 2 years	66		
- Missing Pregnancy Info	65		
Diabetes mellitus without mention of complication	9		
Cystic Fibrosis	0		
Elevated Glycated Hemoglobin > 8	0		
Eligible participants:			3220
Interviewed but not examined*	222	7	
Interviewed and examined:			2998
Participants who did not fast [†]	675	23	
Total sample who fasted for 6 hours or more (Aim 1):			2323
Participants with missing puberty measurements [‡]	261	11	
Total sample who fasted for six hours or more and who had puberty measurements (Aim2):			2062
Participants with missing biomarkers[‡]	392	17	
Participants with all biomarkers missing	1	0	
Total sample who fasted for six hours or more and who have all biomarkers for analysis including tanner measurements (Aim 3):			1931
Total Analytic Sample for factor analysis:			1931

* The % of the total sample is calculated from the total eligible sample after exclusion from participants who were not interviewed or examined; † The % of the total sample for participants who did not fast is calculated from participants who were interviewed and examined; ‡ The % of the total sample is calculated from the sample who fasted for six or more hours

We compared the demographic characteristics of participants (boys and girls) with missing variables (e.g. participants who did not fast for more than 6 hours (n=1192), missing Tanner stage variables, or missing risk factor variables related to MS, to participants who had no variables missing (n=1806) (see table 3.4). We performed chi-square tests in SUDAAN to determine if there were significant differences between eligible participants and non-eligible participants by age, race/ethnicity, poverty income ratio, physical activity (among 17 years and older), television watching (among 16 years and younger) and tobacco use. Overall, there were only slight differences among the two groups. Significant differences were found by age in boys ($p < 0.01$). When looking at Tanner stage (assessed by pubic hair), significant differences between the two groups were found for boys ($p < 0.01$). Thus, the final analytic sample among boys was slightly older and more mature. This was not seen in girls. There were less younger girls but more mature. These data indicate, as expected that girls reach puberty much earlier than boys.

Table 3.4 Select Characteristics of adolescents (12-19 year old) in NHANES III with missing values * compared to adolescents with no missing values

Characteristic	Sample with any missing values						Final Analytic Sample					
	Boys (n=606)			Girls (n=586)			Boys (n=889)			Girls (n=917)		
	N	Total % [†]	SE	N	Total % [†]	SE	N	Total %	SE	N	Total %	SE
Age at Interview (Years)*												
12	100	15.13	1.83	93	12.63	2.09	108	12.77	1.94	111	10.12	1.58
13	79	12.14	1.47	91	12.65	1.94	116	13.68	2.03	130	13.27	1.39
14	84	16.11	2.94	96	20.26	2.82	100	11.67	1.76	114	13.03	1.93
15	74	11.26	2.07	68	12.32	2.44	110	10.46	1.15	105	12.92	1.48
16	70	12.75	2.22	82	14.34	2.00	124	13.61	1.71	125	12.13	1.83
17	84	14.16	2.99	64	9.42	1.85	110	13.12	1.78	117	13.48	1.66
18	70	13.59	2.15	53	11.29	2.76	103	9.89	1.33	102	11.97	1.80
19	45	4.86	1.30	39	7.10	1.92	118	14.81	2.25	113	13.08	2.40
Tanner stage at Interview (pubic hair)												
1	33	4.57	1.27	4	0.90	0.80	61	6.42	1.33	7	1.06	0.49
2	26	3.04	0.94	19	4.70	1.22	46	4.21	1.01	34	3.32	0.89
3	55	8.10	2.31	43	5.63	1.33	87	9.22	1.48	81	7.42	1.44
4	85	16.31	3.29	116	20.98	2.31	183	25.51	2.63	322	35.11	2.52
5	244	37.41	4.13	203	30.92	3.33	512	54.64	3.55	473	53.09	3.02
Missing	163	30.58	6.52	201	36.87	4.64	-	-	-	-	-	-
Race/Ethnicity*												
Non-Hispanic White	138	62.33	4.21	161	64.03	3.80	221	69.42	3.22	241	62.60	3.71
Non-Hispanic Black	231	17.86	2.33	232	18.03	2.25	307	14.14	1.43	306	16.06	2.06
Mexican American	197	7.86	1.32	163	7.31	1.27	331	8.70	1.13	315	9.62	1.35
Other	40	11.95	3.16	30	10.62	2.22	30	7.74	3.33	55	11.73	2.72
Poverty Income Ratio												
< 1	215	20.95	2.52	202	23.89	3.02	294	17.85	2.11	293	21.35	2.43
≥ 1 and < 2	141	24.04	3.03	135	21.37	2.92	237	21.96	2.36	240	22.56	2.80
≥ 2	181	47.35	3.85	189	47.93	4.27	268	49.76	2.78	304	49.99	3.28
Missing	69	7.67	1.30	60	6.81	1.51	90	10.43	2.08	80	6.09	1.47

Table 3.4 Select Characteristics of adolescents (12-19 year old) in NHANES III with missing values * compared to adolescents with no missing values (cont'd)

Characteristic	Sample with any missing values						Final Analytic Sample					
	Boys (n=606)			Girls (n=586)			Boys (n=889)			Girls (n=917)		
	N	Total % [†]	SE	N	Total % [†]	SE	N	Total %	SE	N	Total %	SE
Hours of TV watched yesterday (12-16 years)[#]												
0-1	84	21.56	3.47	122	30.45	3.69	139	29.66	3.63	140	34.90	3.84
2-3	139	41.32	4.47	154	40.03	3.98	177	32.00	2.67	203	31.43	2.87
4-5	145	27.53	3.22	135	25.49	3.10	209	31.60	3.12	210	26.45	3.13
> 5	39	9.59	2.32	19	4.03	1.22	33	6.74	2.00	32	7.22	1.71
Physical activity level (17-19 years)												
Inactive	12	4.70	2.41	214	9.53	2.67	15	3.61	1.53	44	11.38	2.54
Moderate	65	32.21	5.07	73	47.06	4.86	96	30.29	3.95	168	45.40	5.32
Vigorous	120	62.85	5.28	58	42.06	4.30	212	64.42	4.39	114	41.4	5.79
Missing	2	0.24	0.18	1	1.34	1.67	8	1.68	0.84	6	1.78	0.93
Smoking Status[†][#]												
Smoking	63	13.19	2.75	44	13.80	2.39	108	15.20	2.25	66	11.67	1.93
Not Smoking	518	83.43	3.09	529	83.36	2.44	745	80.51	2.45	823	84.07	2.49
Possibly Smoking	25	3.38	1.06	13	2.84	0.99	36	4.29	1.12	28	4.26	1.09

* Missing values include adolescents who fasted for less than 6 hours or adolescents with missing Tanner stage measurements or adolescents missing all biomarkers related to MS. [†] Smoking Status: Smoking: Self-reported tobacco use and cotinine levels > 15 ng/mL; Not Smoking: Self-reported non-tobacco user and cotinine levels ≤ 15 ng/mL; Possibly Smoking: Self-reported non-tobacco user and cotinine levels > 15 ng/mL; # no missing value

3.6 Statistical Analysis

3.6.1 Statistical Software

All analyses were done using SAS (162) and SUDAAN (163) statistical software.

SUDAAN was used to account for the unequal probability of selection (which resulted from the cluster design and over sampling of some groups) through sample weights.

SUDAAN also adjusts for non-coverage and non-response bias, and is used to determine the correct variance estimates (163).

3.6.2 NHANES III Weighting Methodology

Due to the weighted sampling design, each participant did not have the same probability of being selected, therefore the sample weights were used in statistical analysis to produce correct population estimates for the population (154). Overall, sample weight calculations took place in three stages. The first stage involved the calculation of weights to compensate for unequal probabilities of selection. The second stage adjusted for non-response. The third stage used post-stratification of the sample weights to Census Bureau estimates of the United States population (152). We utilized the weights calculated by NHANES for the total NHANES sample, since all the variables used in this analyses were determined across all six years of study.

3.6.3 NHANES III Variance Estimation

Variance estimates were obtained with statistical methods by NHANES III statisticians to assure that results obtained weren't biased and based on a simple random sampling assumption. In the present study we used the Taylor series linearization approach to obtain the variance estimates (154).

3.6.4 Statistical analysis for Aim 1

To examine the distribution and determine the prevalence of biomarkers related to Metabolic Syndrome in boys and girls 12-19 years by age, within gender, race/ethnicity and poverty income ratio

The means, percentile estimates, and estimated standard errors by age within gender, race/ethnicity and poverty income ratio were generated for each of the

biomarkers related to MS. These included BMI-for-age percentiles, waist circumference, triglycerides, total cholesterol, LDL-cholesterol, HDL-cholesterol, serum glucose, systolic blood pressure, diastolic blood pressure and C-reactive protein. SUDAAN, was used to take into account the sampling weights and the complex sample design of the survey. We then determined whether there were any significant differences between age groups by conducting t-tests between each age group within each strata in SUDAAN.

We calculated the prevalence estimates of elevated levels of each risk factor by age, using the cut-off points as suggested by Cook et al. (1). Cook et al. modified the NCEP's ATP III definition of Metabolic Syndrome in adults to be used in adolescents 12-19 years' old also using data from NHANES III(1). They obtained their cut-off points from various pediatric reference data, and we used similar cut-off points in our study (see table 2.5). Elevated blood cholesterol levels for adolescents were determined from the *NCEP Report of the Expert Panel on Blood Cholesterol Levels in Children and Adolescents* (52). According to the *NCEP Report of the Expert Panel on Blood Cholesterol Levels in Children and Adolescents* the HDL-cholesterol borderline range for all sexes is 35 to 45 mg/dL, therefore the midpoint of the range, 40 mg/dL was defined as the cut-off point for low HDL-cholesterol levels. The borderline range for triglyceride levels in children 10-19 years range from 90-129 mg/dL, therefore the midpoint would be 110mg/dL, which again was used as the cut-off value for triglycerides. The cut-off value for LDL-cholesterol was > 130 mg/dL and total cholesterol was ≥ 200 mg/dL (52). The cut-off value for elevated fasting glucose was determined by the American Diabetes Association guidelines, which is 110mg/dL or higher for all children (164). There are currently no reference values for waist circumference in children or adolescents, therefore

abdominal obesity was defined as subjects above the 90th percentile value for their age and sex obtained from this sample population. The same procedure to define waist circumference at the 90th percentile was used by Cook et al. (1). C-reactive protein concentrations were based on two categories: undetectable ($< 0.22\text{mg/dL}$) and elevated ($\geq 0.22 \text{ mg/dL}$) levels which is based on a previous approach taken by Visser et al. when analyzing NHANES III data in children and adolescents (115). High-normal blood pressure is defined as systolic and diastolic blood pressure greater than or equal to the 90th percentile for age, sex and height, and hypertension is defined as systolic or diastolic blood pressure greater than or equal to the 95th percentile for age, sex and height (96).

3.6.5 Statistical analysis for Aim 2

To examine the distribution of biomarkers related to MS in boys and girls 12-19 years by sexual maturation stage (pubic hair assessment) within gender, race/ethnicity and poverty income ratio

A similar analytic approach as in Aim 1 was taken in Aim 2, (see above). The mean, estimated standard error and percentiles of all the biomarkers related to MS were calculated using SUDAAN by stage of sexual maturation within gender, race/ethnicity and poverty income ratio within stage of sexual maturation. We used pubic hair assessments as an indicator of sexual maturity, because this measurement was obtained from both boys and girls and may be less influenced by body fatness than breast development. A similar approach was taken by Cook et al. (1) but for this analysis we calculated prevalence estimates of biomarkers related to metabolic syndrome by sexual maturation stage in boys and girls 12-19 years old. We used t-tests to determine if there

were significant differences between mean values for each biomarker related to MS represented at the different stages within gender, race/ethnicity and poverty income ratio.

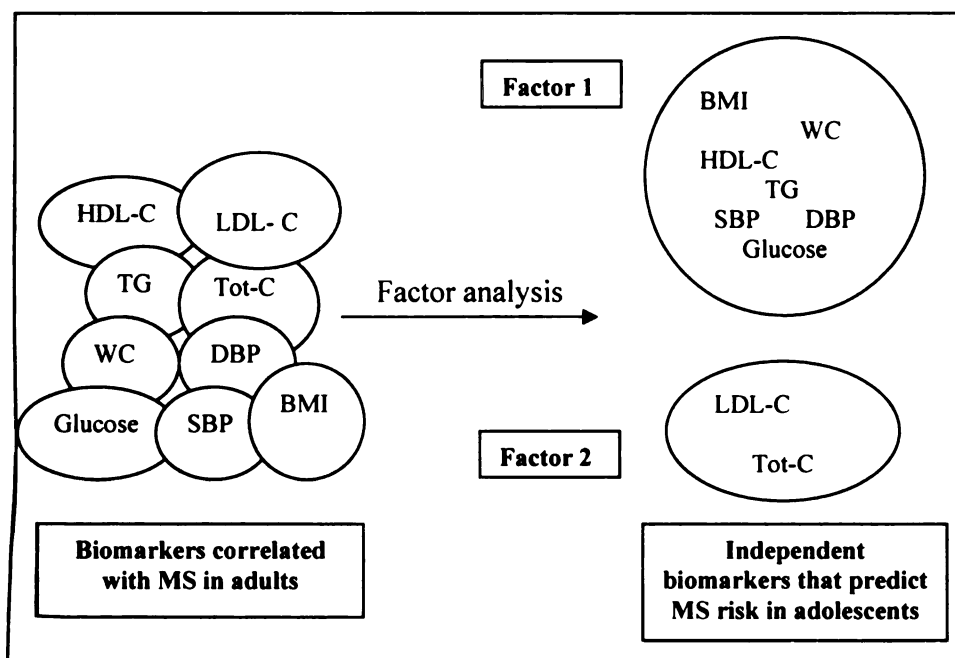
3.6.6 Statistical analysis for Aim 3

*To examine the clustering of biomarkers that have previously been associated with Metabolic Syndrome in adults, in boys and girls 12-19 years using **factor analysis**, and the association between demographic variables and these identified factor scores*

Principal component factor analysis was used to condense the highly intercorrelated biomarkers potentially related to MS. A weighted correlation matrix was created from the biomarkers related to MS using PROC GLM in SAS. This procedure is ran before the factor analysis procedure, in order to account for the complex survey design of NHANES III by pooling the variance and covariance within the sampling stratum. Second, the factor analysis was performed by using the PROC FACTOR procedure using principal component analysis with varimax rotation. The principal-component analysis transforms the original variables into a new set of factor scores or components, which are independent of each other (53). Varimax rotation is used to obtain factor loadings that are orthogonal and independent of each other through the factor procedure. We standardized each variable and then included them into the factor analysis so that each variable had a mean of 0 and a standard deviation of 1. In order to identify the most meaningful factors, factors with eigenvalues (“represents the amount of variance attributable to each component” (53)) greater than 1 were retained. Factor Analysis, therefore, uses the correlation matrix to identify the factors, which assigned to each individual in the dataset a factor score for each factor that varied from high to low. In

these analyses a person loaded high on a factor if the person had a high score for a certain factor or loaded low on a factor if a person had a low score on a factor. Therefore “loading on” a factor is the correlation between each variable and the various factors that cluster with this variable. To determine which variables loaded on each factor we chose a minimum absolute loading value of 0.30. Therefore, any value above or equal to an absolute value of 0.30 would be considered a significant loading on a specific factor. These factor scores were then divided into quartiles and further analyses were done to assess the association between specific demographic variables and the factor scores. An example of the purpose of factor analysis is explained in the diagram (Figure 3.1) below. We start out with many correlated variables (biomarkers for Metabolic Syndrome) which are reconstituted into two relatively non-overlapping circles with different variables (biomarkers in each factor) (165).

Figure 3.1 Diagrammatic representation of the identification of factors (clusters of biomarkers) associated with the risk of Metabolic Syndrome in adolescents 12-19 years old: NHANES III, 1988-1994. Based on Kleinbaum et al. (165)



BMI: BMI-for-age percentiles; WC: Waist Circumference (cm); TC: Total cholesterol (mg/dL); LDL-C: LDL-cholesterol; HDL-C: HDL-cholesterol; TG: Triglycerides; SBP: Systolic blood pressure percentiles; DBP: Diastolic Blood Pressure Percentiles

Chapter 4: Results

4.1 Description of NHANES III population based sample

The following analyses were completed on data that came from the National Health and Nutrition Examination Survey (NHANES III), conducted by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC). This study was carried out in 50 states and the District of Columbia of the United States in two sets of phases, 1988-1991 and 1991-1994. Therefore this sample in Table 4.1 (adolescents 12-19 years old) is representative of the total US adolescent population.

Among girls and boys in this sample who fasted for 6 hours or more, age was evenly distributed and there were no significant differences in the sample number in girls or boys across 12-19 years old. There were slightly younger boys and slightly less older girls in the sample.

The majority of the sample has reached Tanner stage 4 and was non-Hispanic white. There were only a small amount of boys and girls in Tanner stage 1, Tanner stage 2 and Tanner stage 3. The percentage distribution among boys and girls were not significantly different from each other within Tanner stage.

Girls and boys were distributed evenly among poverty income ratio. The majority of boys and girls had a poverty income ratio greater than two. From this latter statement, we can make the assumption that the girls and boys with a poverty income ratio greater than one are probably mostly non-Hispanic white, since most of the adolescents in this sample were non-Hispanic white.

Television watching among girls and boys 12-16 years old was evenly distributed among girls and boys. Girls were more likely to be categorized as inactive (10.45%) compared to boys (4.42%), and boys (62.18%) were also more likely to have vigorous activity levels compared to girls (43.10%). Smoking was evenly distributed among girls and boys, and the majority of adolescents were categorized as non-smokers. In the following results for aim 1 and aim 2 we focused primarily on median values than mean values, since mean values were more likely to be influenced by outliers.

4.2 Results for Aim 1

Aim 1: To examine the distribution and determine the prevalence of biomarkers related to Metabolic Syndrome in boys and girls 12-19 years by age within gender, race/ethnicity and poverty income ratio.

The first analyses describe the mean and standard error for each biomarker related to Metabolic Syndrome (MS) as well as the distribution across each biomarker at the 10th, 50th, and 90th percentile. Each biomarker was examined by age, by age within race/ethnic group and by age within poverty income ratio.

4.2.1 Distributions of biomarkers by chronological age

BMI-for-Age Percentiles

The distribution of BMI-for-age percentiles for boys and girls are described in Table 4.2. In both boys and girls, older children 18-19 years old tend to have lower median percentile values on the BMI-for-age growth charts compared to younger boys and girls.

Among boys, Mexican Americans had higher median percentile levels on the BMI-for-age growth charts compared to non-Hispanic whites and non-Hispanic blacks across all age groups. Non-Hispanic white boys had significantly lower median BMI-for-age percentile values at age 18-19 (48.20) compared to other age groups (12-13 (60.12), 14-15 (69.48) and 16-17 (61.87)). Among girls in all race/ethnic groups, median percentile values tend to decrease slightly with age on the BMI-for-age growth charts. In contrast to boys, non-Hispanic black girls and Mexican American girls both had much higher median percentile values than non-Hispanic white girls across all ages.

Among boys there was no significant linear trend in BMI-for-age percentiles across age groups within poverty income ratio. However, boys 18-19 years old with a poverty income ratio greater than two had significantly lower median values on the BMI-for-age growth charts (38.01) compared to other age groups (12-13 (58.36), 14-15 (67.34), 16-17 (65.44)). Girls, on the other hand, with a poverty income ratio less than one had a much greater median percentile value on the BMI-for-age growth charts compared to girls with a poverty income ratio greater than two.

Waist circumference

In Table 4.3 waist circumference levels are described by age among boys and girls, by age within race/ethnic group and by age within poverty income ratio. In both boys and girls, waist circumference levels increased with age. Waist circumference levels among girls were only slightly less compared to those of boys.

Among race/ethnic groups, non-Hispanic white boys and Mexican American boys had slightly higher waist circumference levels compared to non-Hispanic black boys across all age groups. (For e.g. 18-19 year old Mexican American boys (91.55 cm) and

non-Hispanic white boys (79.49 cm) vs. non-Hispanic black boys (75.90 cm)). Among girls, non-Hispanic blacks had higher waist circumference levels when compared to non-Hispanic whites across all age groups. Mexican American girls also had higher values compared to non-Hispanic whites, but not quite as high as non-Hispanic black girls.

Median waist circumference levels across all age groups among boys with a poverty income ratio less than one, and greater than and equal to one and less than two, were slightly higher compared to median waist circumference levels among boys with a poverty income ratio greater than two. Waist circumference levels in girls also seemed to decrease as poverty income ratio increased.

Triglycerides

Triglyceride levels for boys and girls 12-19 years old are described in Table 4.4. Median triglyceride levels varied by age within boys and girls. Among boys 14-15 years old, median triglyceride levels were much lower (72.30 mg/dL) compared to 12-13 year olds (79.84 mg/d), 16-17 year olds (79.69 mg/dL) and 18-19 year olds (88.06 mg/dL). Whereas among girls 14-15 years old, median triglyceride levels tend to be much higher (75.63 mg/dL) compared to 12-13 year olds (75.23 mg/dL), 16-17 year olds (71.32 mg/dL) and 18-19 year olds (72.22 mg/dL).

Non-Hispanic white boys, followed by Mexican American boys, had higher median triglyceride levels compared to non-Hispanic black boys across all age groups. Among Mexican American girls and non-Hispanic white girls, median triglyceride levels differed at various ages and there was no significant linear trend. However, both non-Hispanic white girls and Mexican American girls had much higher median triglyceride levels compared to non-Hispanic black girls across all age groups.

There was no trend seen in median triglyceride levels, when stratifying by age within poverty income ratio in both boys and girls. Although 18-19 year old boys with a poverty income ratio less than one seem to have very high median triglyceride levels (103.36 mg/dL) compared to the younger age groups (12-13 (72.29 mg/dL), 14-15(70.92 mg/dL), 16-17 (81.33 mg/dL). In contrast, compared to boys 18-19 years old, girls with a poverty income ratio less than one at age 18-19 had a median triglyceride level of 69.84 mg/dL.

Total Cholesterol

Table 4.5 describes the distribution of total cholesterol levels in the adolescent population 12-19 years old. Overall, there was no linear trend in median total cholesterol levels within boys and girls across the different age groups. Girls however, seemed to have slightly higher median total cholesterol levels compared to boys.

Non-Hispanic black boys had higher median total cholesterol levels across all ages compared to non-Hispanic white boys and Mexican American boys. Mexican American boys also had higher levels compared to non-Hispanic white boys but these levels were not as high as non-Hispanic black boys. Among girls similar results were found. Non-Hispanic black girls had higher total cholesterol levels compared to non-Hispanic whites and Mexican Americans across all ages, but in contrast to boys, non-Hispanic white girls had higher total cholesterol levels compared to Mexican American boys.

Boys with a poverty income ratio less than one had greater median total cholesterol levels compared to boys with a poverty income ratio greater than equal to one and less than two and greater than and equal to two. Among girls, the same results were

found, although girls 18-19 years old (176.42 mg/dL), with a poverty income ratio greater than two, had a much higher total cholesterol levels compared to other girls 18-19 years old with a poverty income ratio less than one, and greater than and equal to one and less than two.

HDL-Cholesterol

Table 4.6 describes the distribution of HDL-cholesterol levels in boys and girls 12-19 years old. HDL-cholesterol levels decreased with age in boys across all age groups. There was no such linear trend in girls, but girls did have higher HDL-cholesterol levels across all ages compared to boys.

Non-Hispanic white boys had slightly lower median HDL-cholesterol levels compared to non-Hispanic black boys and Mexican American boys across all ages. Non-Hispanic black boys had the highest HDL-cholesterol levels compared to the other race/ethnic groups. Similar results but not as dramatic, were found in girls.

Across all ages boys with a poverty income ratio greater than two had lower HDL-cholesterol levels compared to boys with a poverty income ratio less than one. Among girls no significant differences were seen by age within poverty income ratio.

LDL-Cholesterol

In Table 4.7 we reported the distribution of LDL-cholesterol in boys and girls 12-19 years old by age, by age within race/ethnic group and by age within poverty income ratio. There was no significant linear trend in median LDL-cholesterol levels across all age groups in boys and girls. LDL-cholesterol levels were similar among both boys and girls with only slight observable differences across age groups. Among older children 14-15 years (91.01 mg/dL for girls vs. 88.66 mg/dL for boys), 16-17 years (89.02 mg/dL for

girls vs. 86.60 mg/dL for boys) and 18-19 years (99.04 mg/dL for girls vs. 92.54 mg/dL for boys), girls seemed to have slightly higher median LDL-cholesterol levels.

Among both boys and girls across all ages, non-Hispanic blacks had higher median LDL-cholesterol levels compared to non-Hispanic whites and Mexican Americans. There were no significant differences across age groups within each poverty income ratio for boys or girls.

Glucose

Glucose levels for boys and girls 12-19 years old are described in Table 4.8. Glucose levels remained constant across age groups in both boys and girls. Boys had higher median glucose levels compared to girls across all ages.

Non-Hispanic white boys and Mexican American boys had slightly higher median glucose levels compared to non-Hispanic black boys at all ages. Differences however between non-Hispanic white boys and Mexican American boys were very insignificant. Among girls similar results were found, in that non-Hispanic white girls and Mexican American girls had higher median glucose levels compared to non-Hispanic black girls. No significant differences were found among age groups within poverty income ratio.

Systolic Blood Pressure

In table 4.9 the distribution of systolic blood pressure percentiles in boys and girls 12-19 years old are reported. Overall, there was no linear trend in median systolic blood pressure percentiles across age groups in boys and girls. Girls tend to have slightly lower median systolic blood pressure percentiles compared to boys.

Both Mexican American boys and non-Hispanic black boys had higher median systolic blood pressure percentiles compared to non-Hispanic white boys across all ages.

Among girls, non-Hispanic black girls had higher median systolic blood pressure percentiles compared to non-Hispanic white and Mexican American girls.

Boys with a poverty income ratio greater than two had lower median systolic blood pressure percentiles compared to boys with a poverty income ratio less than one, and boys with a poverty index greater than one and less than two. Among girls no significant differences were seen in systolic blood pressure percentiles by age within poverty income ratio.

Diastolic Blood Pressure

In Table 4.10 diastolic blood pressure percentiles are described by age among boys and girls, by age within race/ethnic group and by age within poverty income ratio. Diastolic blood pressure percentiles in boys and girls increased with age, but the increase was very slight. An interesting finding was that among all race/ethnic groups 18-19 year old boys and girls had significantly higher median diastolic blood pressure percentile values compared to the other age groups. Older non-Hispanic black boys and girls had higher diastolic blood pressure percentiles compared to older non-Hispanic white and Mexican American boys and girls. There was no significant linear trend among boys or girls by age within poverty income ratio.

4.2.2 Prevalence estimates of elevated levels of biomarkers of MS in boys and girls 12-19 years old by age

In Table 4.11 we estimated the prevalence of elevated biomarkers related to MS in boys and girls 12-19 years old by age. Cut-off values for elevated biomarkers were based on similar cut-off values as used by Cook et al. (1). Among boys 12-13 years old,

20.43% were classified as being at risk for overweight, where among 18-19 year old boys only 7% were classified as being at risk for overweight. In contrast to this, 10.43% of boys 12-13 years old were classified as being overweight and 11.30% 18-19 years olds were classified as being overweight. Girls on the other hand were more likely to be at risk for overweight between ages 14-17 (14-15 (18.39%) and 16-17 (17.30%)), and were more likely to be overweight at younger ages (12-13, 13.37%) compared to older ages (18-19, 9.24%).

Among boys waist circumference prevalence estimates seemed to be similar across age groups, and increased slightly in boys 18-19 years old. Among girls the prevalence estimates for waist circumference levels seemed to increase very slightly between ages 14-17, and was lower at ages 12-13 and 18-19. We can make the assumption that almost 10% of boys and girls in the US adolescent population had elevated waist circumference levels.

Prevalence estimates for elevated triglyceride levels were very high among boys. Almost one third of 16-17 year olds and 18-19 year old boys had elevated triglyceride levels. Whereas among girls prevalence estimates for elevated triglyceride levels seemed to stay constant throughout ages 12-19 and 20% of female adolescents in the population according to these results have elevated triglyceride levels.

Low HDL-cholesterol levels were highly prevalent in boys across all age groups. Boys 12-13 years old had the lowest prevalence estimates for low HDL-cholesterol levels. Almost 40% of boys 18-19 years old had low levels of HDL-cholesterol, which puts them at risk. Among girls prevalence estimates were much lower compared to boys, although 21% of girls 16-17 years old had low HDL-cholesterol levels.

Overall the prevalence estimates for glucose levels among boys and girls were very low compared to the prevalence estimates of other variables in our sample, and there were no significant differences across age groups. Total-cholesterol prevalence estimates increased with age in boys and were highest at age 18-19, where almost 15% of boys in the population had elevated total cholesterol levels according to the NCEP definition. Among girls the prevalence estimates were also highest for girls 18-19 years old.

Prevalence estimates for elevated LDL-cholesterol levels in boys was significantly lower for boys 14-15 years old (4.24%) compared to boys 18-19 years old (13.23%). Among girls, prevalence estimates for elevated LDL-cholesterol levels seem to increase with age, and ranged from 7.7% for 12-13 year old girls to 15.24% for 18-19 year old girls.

Prevalence estimates for high normal systolic blood pressure percentiles among boys were similar across age groups, except 4.57% of boys 18-19 years old were classified between the 90th and 95th percentiles i.e. they have high-normal systolic blood pressure. Five percent of Boys 12-13 years old were classified as having hypertension ($\geq$ 95th percentile) whereas prevalence estimates along other age groups were very low. Among girls prevalence estimates for high-normal blood or hypertension was very low. Only approximately 2% of girls in the adolescent population had systolic blood pressure levels above the 85th percentile.

Prevalence estimates for elevated diastolic blood pressure were also very low in both boys and girls. Almost no adolescents had elevated diastolic blood pressure, when classifying them by the age-height-sex-specific percentiles.

Elevated C-reactive protein levels among boys were more prevalent among 14-17 years old, but this was not found to be significant. Among girls however, prevalence estimates for C - reactive protein increased by age. Almost 20-25% of girls 18-19 years old are classified with elevated C-reactive protein levels.

4.2.3 Conclusion

These data indicate that the distribution of biomarkers varied in the population by age, gender, race/ethnicity and poverty income ratio. BMI-for-age percentiles decreased by age in boys and girls and were higher in Mexican American boys and non-Hispanic black and Mexican American girls. Waist circumference levels increased by age and were higher in non-Hispanic white and Mexican American boys and higher in non-Hispanic black girls. Triglyceride levels were highest in non-Hispanic white and Mexican American boys and girls, and there was no significant trend by age. Total cholesterol levels and LDL-cholesterol levels were higher among non-Hispanic black boys and girls. HDL-cholesterol levels decreased with age in boys and increased with age in girls. Among boys and girls non-Hispanic whites had lower HDL-cholesterol levels compared to non-Hispanic black and Mexican American boys and girls. Glucose levels were fairly equally distributed among age and non-Hispanic white boys and Mexican American and non-Hispanic white girls had higher glucose values across all ages. Systolic and diastolic blood pressure percentiles were higher among non-Hispanic black boys and girls, but among boys, Mexican Americans also had higher systolic blood pressure percentiles

Prevalence estimates of elevated levels of biomarkers related to MS varied by age for each biomarker. High levels of BMI-for-age percentiles ($\geq 85^{\text{th}}$ and $< 95^{\text{th}}$ BMI-for-

age percentiles) and ($\geq 95^{\text{th}}$ BMI-for-age percentiles)), waist circumference, triglycerides and HDL-cholesterol were found in approximately 10% or more of boys and girls across all age groups. High total cholesterol, LDL-cholesterol and C-reactive protein prevalence estimates also occurred in a significant amount of adolescents in the population.

Prevalence estimates of high glucose levels, systolic and diastolic blood pressure percentiles were very low. We therefore can conclude that prevalence estimates of elevated levels of biomarkers related to MS varied substantially by age.

4.3 Results for Aim 2

Aim 2: To examine the distribution of biomarkers related to MS in boys and girls 12-19 years old by sexual maturation stage (pubic hair assessment) within gender, race/ethnicity and poverty income ratio

The second analyses describe the mean and standard error for each biomarker related to Metabolic Syndrome (MS) as well as the distribution across each biomarker at the 10th, 50th, and 90th percentile. Each biomarker was examined by Tanner stage, by Tanner stage within race/ethnic group and by Tanner stage within poverty income ratio. The sample size for girls at Tanner stage one was very small, therefore those results were found to be insignificant and will not be discussed.

4.3.1 Distributions of Biomarkers by Sexual Maturation Stage

BMI-for-age Percentiles

Table 4.12 describes the BMI-for-age percentiles for boys and girls by Tanner stage. At Tanner stage 1, boys were more likely to be below the 50th percentile on the

BMI-for-age growth charts. At Tanner stage 2 there was a significant increase from 39.25 for boys at Tanner stage 1 to 67.18 for boys at Tanner stage 2. The median percentile values then tend to decrease at Tanner stage 3 (58.42) and 4 (52.11) and then increased again at Tanner stage 5 (59.99). Girls followed a similar pattern as boys and had higher median percentile values on the BMI-for-age growth charts compared to boys.

BMI-for-age percentiles displayed considerable differences among race/ethnic groups and there was no linear trend from Tanner stage 1 to Tanner stage 5 for boys or girls. Non-Hispanic black girls had higher median BMI-for-age percentiles on the growth charts compared to non-Hispanic black boys. There was no significant trend found among poverty income ratio, although girls with a poverty income ratio less than one had slightly higher median BMI-for-age percentile levels compared to girls with a poverty income ratio greater than two.

Waist Circumference

The distribution of waist circumference levels are reported in Table 4.13. Median waist circumference levels in boys were slightly higher at Tanner stage 2 (75.65 cm) compared to the other Tanner stages, and then increased again at Tanner stage 5 (77.23 cm). Among girls the same trend was found.

Overall among boys, non-Hispanic white boys and Mexican American boys had higher median waist circumference levels compared to non-Hispanic black boys at all Tanner stages. Mexican American boys at Tanner stage 5 had significantly higher median levels compared to the other stages. Among girls, Mexican Americans had higher median waist circumference levels at all Tanner stages compared to non-Hispanic whites and non-Hispanic blacks although the differences were not extreme. Overall, boys

and girls with a poverty income ratio less than one had slightly higher median waist circumference levels, compared to boys and girls with a poverty income ratio greater than and equal to two.

Triglycerides

In Table 4.14 the triglyceride levels for boys and girls by Tanner stage, by Tanner stage within race/ethnic group and by Tanner stage within poverty income ratio are reported. There was no significant trend for triglyceride levels across sexual maturation stages for boys or girls. Boys had slightly higher median triglyceride levels compared to girls at all Tanner stages except Tanner stage 4, where median values among boys and girls were found to be equal.

Non-Hispanic white boys at Tanner stage 2, 3, 4 and 5 had higher median triglyceride levels compared to non-Hispanic black boys. Mexican American boys also had higher median triglyceride levels compared to non-Hispanic black boys. Mexican American girls had higher median triglyceride levels compared to non-Hispanic white and non-Hispanic black girls. There was no trend among sexual maturation stages within poverty income ratio for boys or girls.

Total Cholesterol

In Table 4.15 total cholesterol levels are described by Tanner stage among boys and girls, by Tanner stage within race/ethnic group and by Tanner stage within poverty income ratio. Boys at Tanner stage 1 (170.94 mg/dL) and Tanner stage 2 (172.09 mg/dL) had median total cholesterol levels that were much higher than Tanner stage 3 (162.19 mg/dL), Tanner stage 4 (148.07 mg/dL) and Tanner stage 5 (155.27 mg/dL). Median

total cholesterol levels at Tanner stage 1 and Tanner stage 2 were also higher for boys compared to median total cholesterol levels for girls at Tanner stage 1 (150.60 mg/dL) and Tanner stage 2 (158.09 mg/dL).

Non-Hispanic black boys had higher median total cholesterol levels at all sexual maturation stages compared to non-Hispanic white boys and Mexican American boys. Similar results were found for girls. Almost at all sexual maturation stages it seemed like girls had slightly higher median total cholesterol levels compared to boys across all race ethnic groups.

Among boys median total cholesterol levels were slightly lower if they had a poverty income ratio greater than and equal to two, compared to boys with a poverty income ratio less than one. Among girls there were no significant differences among Tanner stage within poverty income ratio.

HDL-Cholesterol

A description of HDL-cholesterol levels are reported in Table 4.16 within boys and girls by Tanner stage. Among boys median HDL-cholesterol levels decreased with increasing Tanner stage. Among girls no significant differences were found. Girls tend to have higher median HDL-cholesterol levels compared to boys, except at Tanner stage 2 where boys (50.00 mg/dL) had a higher median HDL-cholesterol level compared to girls (46.74 mg/dL).

Non-Hispanic white boys and Mexican American boys had slightly lower median HDL-cholesterol levels compared to non-Hispanic black boys at all sexual maturation stages. Among girls, non-Hispanic white girls had lower median HDL-cholesterol levels compared to non-Hispanic black girls and Mexican American girls.

Boys with a poverty income ratio less than one had higher median HDL-cholesterol levels at Tanner stage 1 through Tanner stage 4 compared to boys with a poverty income ratio greater than and equal to two. Among girls no significant differences were found within poverty income ratio by Tanner stage.

LDL-Cholesterol

Table 4.17 describes the LDL-cholesterol levels for boys and girls by Tanner stage. Median LDL-cholesterol levels were higher in boys than in girls at Tanner stage 1 (105.27 mg/dL vs. 75.55 mg/dL), Tanner stage 2 (103.45 mg/dL vs. 88.47 mg/dL) and Tanner stage 3 (94.69 mg/dL vs. 93.20 mg/dL). At Tanner stage 4 girls had higher median LDL-cholesterol levels than boys (91.98 mg/dL vs. 83.20 mg/dL), and at Tanner stage 5 median LDL-cholesterol levels were equal among boys and girls (90.07 mg/dL for boys vs. 90.08 mg/dL for girls).

Among boys, non-Hispanic blacks had higher median LDL-cholesterol levels compared to non-Hispanic white and Mexican Americans across all Tanner stages. In girls median LDL-cholesterol levels varied across race/ethnic groups by sexual maturation stage, and there was no significant trend. For both boys and girls, there were no significant differences between sexual maturation stages within poverty income ratio.

Glucose

In Table 4.18 glucose distribution among boys and girls 12-19 years old are discussed. Overall levels remained constant for boys and girls from Tanner stage 1 through to Tanner stage 5. Median glucose levels for boys were higher than for girls at all Tanner stages except for Tanner stage 3 where girls had slightly higher median

glucose levels compared to boys. Median levels also stayed constant between sexual maturation stages among race/ethnic groups and poverty income ratio.

Systolic Blood Pressure Percentiles

The distribution of systolic blood pressure percentiles are reported in tables 4.19 among boys and girls. Median systolic blood pressure percentiles were higher among boys compared to girls but did not decrease nor increase with increasing Tanner stage.

Non-Hispanic black boys and non-Hispanic black girls tend to have higher median systolic blood pressure percentiles compared to non-Hispanic white boys and non-Hispanic white girls. Overall Mexican American boys and girls also had higher median systolic blood pressure percentile levels compared to non-Hispanic white boys and girls, but not as high as non-Hispanic black boys and girls.

There was no significant trend between sexual maturation stages in each poverty income ratio. Boys with a poverty income ratio less than one had higher median systolic blood pressure percentile values at Tanner stage one and two compared to boys with a poverty income ratio greater than and equal to two.

Diastolic Blood Pressure Percentiles

The distribution of diastolic blood pressure percentiles are reported in tables 4.20 among boys and girls. Median diastolic blood pressure percentiles values were higher for boys than girls at all sexual maturation stages, and for girls from Tanner stage 3 median diastolic blood pressure percentiles seemed to increase with increasing Tanner stage.

Non-Hispanic black boys and girls had higher median diastolic blood pressure percentiles at Tanner stage 3, Tanner stage 4, and Tanner stage 5 when comparing to non-Hispanic white boys and girls. Non-Hispanic black girls also had higher median diastolic

blood pressure percentiles compared to Mexican American girls, but Mexican American boys had higher values than non-Hispanic black boys at Tanner stage 2 and Tanner stage 5. There were no significant differences between sexual maturation stages when stratifying by gender within poverty income ratio.

4.3.2 Prevalence estimates of elevated levels of biomarkers related to MS in boys and girls by sexual maturation stage

Boys

Table 4.21 describes the prevalence estimates of elevated levels of biomarkers of MS in boys 12-19 years old by sexual maturation stage. Cut-off values for elevated biomarkers were again based on similar cut-off values as used by Cook et al. (1). Among boys, 15% and more were classified as being at risk for overweight from Tanner stage 1 through Tanner stage 5. The prevalence estimate for overweight boys tend to increase by Tanner stage, and then decrease dramatically at Tanner stage 4 after which it increases again at Tanner stage 5. Elevated waist circumference levels showed a similar pattern as overweight in boys. Prevalence estimates increased from Tanner stage 1 (7.99 %) through to Tanner stage 3 (17.86 %), and then decreased at Tanner stage 4 (5.67 %), after which it then increased again in Tanner stage 5 (11.94%).

Prevalence of elevated triglyceride levels increased at Tanner stage 2 (28.16 %), Tanner stage 3 (25.55 %) and Tanner stage 5 (26.10%) and was lower at Tanner stage 1 (9.36%) and Tanner stage 4 (16.47%). Prevalence estimates for low HDL-cholesterol levels increased significantly with increasing sexual maturation stage.

Boys at Tanner stage 2 were more likely to have elevated glucose levels compared to other stages. Overall the prevalence estimates for elevated glucose levels was low across all Tanner stages. Prevalence estimates for elevated total cholesterol levels in boys varied by Tanner stage, and there was no significant increasing or decreasing trend. Boys at Tanner stage 5 had the highest prevalence estimate for elevated total cholesterol levels.

Similar results were found for elevated LDL-cholesterol levels. Prevalence estimates for elevated LDL-cholesterol levels were highest in boys at Tanner stage 5. Prevalence estimates for high-normal blood pressure and hypertension were very low at all Tanner stages. Elevated C - reactive protein levels in boys increased slightly from Tanner stage 1(3.70%) and Tanner stage 3 (11.78%) and then stayed fairly constant at Tanner stage 4 (9.80%) and 5 (10.34%).

Girls

Table 4.22 describes the prevalence estimates of elevated levels of biomarkers of MS in girls 12-19 years old by sexual maturation stage. Cut-off values for elevated biomarkers were also based on similar cut-off values as used by Cook et al. (1). Girls were more likely to be at risk for overweight at Tanner stage 2 (29.45%) and again at Tanner stage 5 (17.91%). Whereas they were more likely to be overweight at Tanner stage 3 (13.35%) and Tanner stage 4 (11.56%) compared to Tanner stage 2(6.14%) and Tanner stage 5 (8.66%). Almost a third of the female adolescent population was at risk for overweight at Tanner stage 2 (29.45%).

Prevalence estimates for elevated waist circumference levels were greater at Tanner stage 3 (17.75%) and at Tanner stage 5 (12.17%). Elevated triglyceride level

prevalence estimates were higher at Tanner stage 2(29.12%) and Tanner stage 3 (27.91%) and decreased significantly at Tanner stage 4 (17.92%).

Prevalence estimates for decreased HDL-cholesterol levels seemed to be higher at Tanner stage 2 (20.19%) compared to Tanner stage 3 (18.79%), Tanner stage 4 (13.38%) and Tanner stage 5 (16.39%). Prevalence estimates for elevated total cholesterol and elevated LDL-cholesterol levels were highest at Tanner stage 3 and Tanner stage 5. The prevalence of normal-high blood pressure as well as hypertension was low for girls at all sexual maturation stages.

Prevalence estimates of elevated C-reactive protein levels were higher among girls than boys. Seventeen percent (17%) of girls at Tanner stage 2 had elevated C - reactive protein levels compared to 9% of girls at Tanner stage 3, 11% of girls at Tanner stage 4 and 12% of girls at Tanner stage 5.

4.3.3 Conclusion

These data indicate that the prevalence of biomarkers related to metabolic syndrome fluctuated by Tanner stage in boys and girls depending on the biomarker studied. BMI-for-age differed by Tanner stage in boys and girls as did waist circumference levels. Non-Hispanic white boys and Mexican American boys and Mexican American girls had higher waist circumference levels at all Tanner stages. Also boys with a poverty income ratio less than one had higher waist circumference levels. Triglyceride levels showed no differences between Tanner stage for boys or girls, and non-Hispanic white and Mexican American girls had higher levels. Total cholesterol levels in boys were higher at Tanner stage 1 and Tanner stage 2 and stayed fairly constant

in girls. Both non-Hispanic black boys and girls had higher total cholesterol levels across all Tanner stages. In boys HDL-cholesterol levels decreased with increasing Tanner stage was lower in non-Hispanic white boys and Mexican American boys and non-Hispanic white girls. LDL-cholesterol levels varied in boys and girls within Tanner stage and non-Hispanic black boys and girls had higher LDL-cholesterol levels compared to other race/ethnic groups. Glucose levels remained constant at all Tanner stages and systolic blood pressure percentiles were higher in boys than in girls, and higher in non-Hispanic black boys and girls. Diastolic blood pressure percentiles differed by Tanner stage and race/ethnicity and no linear trend was found.

We also conclude that extreme levels of biomarkers related to MS fluctuated by Tanner stage in terms of their prevalence in both boys and girls. It does seem as though boys in Tanner stage 2 and girls in Tanner stage 3 were more likely to have the highest prevalence estimates for all elevated biomarkers. However, there is no clear pattern of when elevated levels of biomarkers related to MS occur.

4.4 Results for Aim 3

Analyses to address Aim 3 of this study are described below. The overall aim was to examine the clustering of biomarkers of boys and girls 12-19 years that have been associated with Metabolic Syndrome (MS) in adults. We used factor analysis to identify patterns of biomarkers (represented as factor loading scores). We examined the association between demographic variables and the identified overall factor scores both within strata of chronological age and Tanner stage. The first analyses done in aim 3 were

to look at the correlations between biomarkers related to MS in boys and girls 12-19 years old by chronological age and by Tanner stage.

4.4.1 Correlations

Overall Sample – Boys and Girls

Overall there were no substantial differences in correlations of biomarkers related to MS between boys and girls within age or within Tanner stage. Boys and girls in this sample were remarkably similar. Some slight differences in correlations (Table 4.23) between boys and girls were that systolic blood pressure percentiles in boys ($r=0.26$) were more correlated with triglyceride levels than in girls ($r=0.05$). Systolic blood pressure percentiles in boys ($r=0.23$) were also more correlated with waist circumference levels compared to girls ($r=0.01$). All other correlations among variables were similar in both boys and girls.

Boys by Age

Table 4.24 list the correlations between biomarkers related to MS for boys within each age group. Among boys there were no significant differences in correlations by age. Some interesting observations were that in younger boys 12-13 years old, total cholesterol levels were negatively correlated with BMI-for-age percentiles ($r=-0.13$). As boys became older, the correlation between BMI-for-age and total cholesterol became more strongly and positively correlated (14-15 ($r=-0.04$), 16-17 ($r=0.12$), 18-19 ($r=0.25$)). Similar results among boys were found for LDL-cholesterol levels and BMI-for-age.

BMI-for-age percentiles in older boys tend to develop a strong positive correlation with glucose levels whereas in the younger boys this association was quite

weak (18-19 ($r=0.25$), 16-17 ($r=-0.00$), 14-15 ($r=0.12$), 12-13 ($r=0.12$). The strong correlation between total cholesterol and HDL-cholesterol seem to decrease with age. Triglyceride levels were strongly negatively correlated with HDL-cholesterol levels at all ages (12-13 ($r=-0.36$), 14-15($r=-0.25$), 16-17($r=-0.45$), 18-19($r=-0.30$)).

Girls by Age

Results for girls (table 4.25) were similar to boys, i.e. there were no substantial differences in correlations between biomarkers related to metabolic syndrome by age. However, triglyceride levels were negatively correlated to BMI-for-age in younger adolescents, compared to a positive correlation between BMI-for-age and triglyceride levels at an older age (12-13 ($r=-0.03$), 14-15 ($r=0.30$), 16-17($r=0.15$), 18-19($r=0.31$)).

An interesting finding was that waist circumference levels were negatively correlated with total cholesterol at all ages, except 16-17 year old girls who had a positive correlation with total cholesterol ($r=0.21$). No other significant differences were found.

Boys and Girls by Tanner stage

Table 4.26 and Table 4.27 presents the correlations between biomarkers related to MS in girls and boys 12-19 years old by Tanner stage 4 and Tanner stage 5, as well as Tanner stage 4 and 5 combined. We combined Tanner stage 4 and 5 because correlations were similar in Tanner stage 4 and Tanner stage 5 in both boys and girls. We anticipated that factor loading scores would be similar among boys and girls in Tanner stage 4 and Tanner stage 5, but this result was not found (discussed below).

4.4.2 Conclusion

In summary from the results above we conclude that correlations between biomarkers of MS were similar for boys and girls by age and Tanner stage, and there were no substantial differences. In the following analyses which involve the factor loading matrices we therefore combined boys and girls in our sample (which would be referred to as overall sample) based on the assumption that correlations between biomarkers did not produce any significant differences.

4.4.3 Factor loading matrix for biomarkers related to MS in boys and girls by age and Tanner stage

Tables 4.28 through Table 4.32 represent the factor loading matrices for biomarkers related to MS in boys and girls 12-19 years old. First we utilized the factor analysis procedure including boys and girls in the overall sample based on the conclusion that the correlations were so similar among boys and girls. Second we utilized the factor analysis procedure by gender because it was more biologically plausible. We then also stratified by age and Tanner stage to see if there were any significant differences by these covariates. Overall, the factors obtained varied considerably by both age and Tanner stage in boys and girls. We believe that the sample sizes by age and Tanner stage were too small to produce stable estimates. Therefore we identified the most meaningful factors in boys and girls were when we pooled the total sample for each gender (boys and girls) and also when broken down by gender (referred to as total sample for boys and total sample for girls).

In these results we will therefore discuss only the factors obtained in the overall sample and the total sample for boys and total sample for girls presented in Table 6. Adolescents in factor 1 of the overall sample and Boys in factor 1 of the total sample loaded high and positive on BMI-for-age percentiles, waist circumference levels and high but negative on HDL-cholesterol levels. They also loaded slightly high on triglycerides but not as high. This factor is the most closely representative of the definition for Metabolic Syndrome in adults.

Factor 2 in the overall sample and factor 2 in the total sample in boys loaded high on total cholesterol and LDL-cholesterol. Factor 3 in the overall sample differed from factor 3 in the total sample for boys. Factor 3 in the overall sample loaded high on systolic blood pressure percentiles and diastolic blood pressure percentiles. Whereas factor 3 in the total sample for boys loaded high on HDL-cholesterol and LDL-cholesterol.

Girls, however, showed a very different pattern than boys. Factor 1 in girls was identical to Factor 2 in the overall sample and the Factor 2 in the total sample for boys. Factor 1 in girls also loaded high on total cholesterol and LDL-cholesterol. Factor 2 in girls loaded high on BMI-for-age percentiles and high on waist circumference levels, and high but negatively on glucose levels. Factor 3 in girls loaded high on glucose, systolic blood pressure percentiles and diastolic blood pressure percentiles, and factor 4 in girls loaded high and positive on triglycerides and glucose and high but negative on HDL-cholesterol.

The first three factors obtained for the overall sample which included boys and girls explained 60% of the variance out of all the other factors that were not included in

the results since they did not have eigenvalues greater than one. The first three factors in the total sample for boys as well as the first three factors in the total sample for girls also accounted for 60% of the variance explained.

4.4.4 Demographic characteristics of factor loading scores for boys and girls

Demographic characteristics of the factor loading scores for Factor 1, Factor 2 and Factor 3 are presented in Table 4.33, Table 4.34 and Table 4.35. Physical activity was assessed only in 17-19 year old and television watching only in 12-16 year olds, therefore quartiles was no longer evenly distributed among those 2 groups. This is due to the fact that circulation of quartiles was based on the overall sample, the total sample for boys and the total sample for girls.

Factor 1 – Overall Sample (Boys and Girls)

We described the demographic characteristics of the overall sample for boys and girls combined in Table 4.33. Factor 1 loaded high and positively on BMI-for-age percentiles, waist circumference and negatively but high on HDL-cholesterol. Factor 1 also loaded high and positively on triglycerides but less significantly. Adolescents in the lowest quartile of factor 1 were more likely to be younger. Adolescents in the highest quartile of factor 1 were more likely to be older (16-19) compared to adolescents in the lowest quartile.

Adolescents in lowest quartile of factor 1 were more likely to be in Tanner stage 1 and adolescents in the highest quartile were more likely to be at Tanner stage 2. Non-Hispanic white and Mexican American adolescents were more likely to be in the highest quartile of factor 1 compared to non-Hispanic blacks. Also adolescents with a poverty

income ratio less than one were more likely to be in the highest quartile of factor 1, but these differences were not significant. Adolescents who were in the highest quartile of factor one were more likely to smoke (41.13% vs. 15.05% in lowest quartile)), be inactive (46.23% vs. 14.93 in the lowest quartile) and watch 4-5 hours of television the day before the interview (31.17% vs. 32.13% in the lowest quartile who watched only 0-1 hour).

Factor 2 – Overall sample (Boys and Girls)

Demographic characteristics of Factor 2 for the overall sample were discussed in Table 4.33. Overall adolescents in the lowest quartile of factor 2 seemed to be between the ages of 14-17, where as adolescents in the highest quartile seemed to be between 18-19 years old. In contrast to this, adolescents in the highest quartile of factor 2 were more likely to be in Tanner stage 1 (36.92 %) and Tanner stage 2 (33.28 %), where as adolescents in the lowest quartile were more likely to be in Tanner stage 4 (35.52%).

Non-Hispanic blacks (28.24 %) were more likely to be in the highest quartile of factor 2 compared to non-Hispanic whites (21.67%) and Mexican Americans (22.99%). Adolescents in the highest quartile of factor 2 were more likely to have a poverty income ratio less than one (25.29%), but adolescents in the lowest quartile of factor 2 had a similar percentage distribution (28.64%) as adolescents in the highest quartile.

Adolescents in the highest quartile of factor 2 where more likely to smoke, be categorized as moderate physical activity and watch 4-5 hours of television the day before the interview. And the opposite was found for participants in the lowest quartile. They were more likely to be non-smokers, and be classified as having vigorous physical

activity levels. Television watching was the same among all groups in the lowest quartile of factor 2.

Factor 3 – Overall sample (Boys and Girls)

In Table 4.33, the demographic characteristics of adolescents in factor 3 are reported. Adolescents in factor 3 loaded high on systolic and diastolic blood pressure. Adolescents in the highest quartile of factor 3 were more likely to be 12-13 years old (28.05%) and 18-19 years old (27.47%), whereas adolescents in the lowest quartile were more likely to be 16-17 years old. Adolescents in the lowest quartile of factor 3 were more likely to be in Tanner stage 2, and we did not see a clear distribution of adolescents in the highest quartile of factor 3. Again the percentage distribution among the highest and lowest quartile was evenly distribution among race/ethnic group as well as poverty income ratio, therefore no considerable differences were found.

Adolescents in the highest quartile of factor 3 were more likely to be classified as smokers and possible smokers, but these differences were not significant. Also adolescents in the highest quartile were more likely to have vigorous levels of physical activity (28.15%) vs. adolescents in the lowest quartile of factor 3 were more likely to have inactive physical activity levels (34.77%). In contrast to the physical activity levels, adolescents in the highest quartile of factor 3 were more likely to watch television for 5 hours or more the day before the interview.

Summary of Factor 1, Factor 2 and Factor 3 – Overall Sample

We can conclude from the results in table 4.33 that factor 1 and factor 2 seemed to be the most meaningful and interpretable factors and accounted for 48% of the total variance explained. Adolescents in the highest quartile of factor 1 were more likely to be

older, be at Tanner stage 2 and were more likely to be non-Hispanic white and Mexican American. They were also more likely to have a poverty income ratio of less than one, be classified as smokers, have an inactive physical activity level and watch 4-5 hours of television per day.

Adolescents in the highest quartile of factor 2 were more likely to be younger, and be in Tanner stage 1 and Tanner stage 2. They were also more likely to be non-Hispanic black and have a poverty income ratio less than one. Furthermore they were more likely to be classified as smokers, have moderate physical activity levels and watch 4-5 hours of television per day.

As mentioned above the last factor (factor 3) was the least interpretable factor in that adolescent the highest quartile were younger (12-13) and older (18-19). They were also more likely to be in Tanner stage 1. In the lowest and highest quartile they were evenly distributed among race/ethnic groups and poverty income ratio. They were more likely to be classified as smokers and possible smokers, have vigorous physical activity levels and watch more than 5 hours of television per day.

Factor 1 – Total Sample for Boys

Table 4.34 represents the demographic characteristics by factor loading scores in boys. Boys in factor 1 loaded high on BMI-for-age percentiles, waist circumference levels, and high but negative on HDL-cholesterol levels. They also loaded slightly high on triglyceride levels. Boys 18-19 years old were more likely to be in the highest quartile of factor 1, and younger boys 12-13 years old were more likely to be in the lowest quartile of factor 1.

When comparing pubertal measurements, boys at Tanner stage 1 were more likely to be in the lowest quartile for factor 1, whereas the percentage of boys at Tanner stage 2 (29.55%), Tanner stage 3 (27.86%) and Tanner stage 5 (30.29%) were almost equally distributed in the highest quartile of factor one. Therefore approximately 30% of boys in Tanner stage 2, Tanner stage 3 and Tanner stage 5 were in the highest quartile of factor 1.

Mexican American boys (33%) were more likely to be in the highest quartile for factor one followed by non-Hispanic white boys (28.29 %). Non-Hispanic black boys (14.82 %) were the least likely to be in the highest quartile for factor 1. Boys with a poverty income ratio less than one were more likely to be in the highest quartile for factor 1, but differences were not very large when comparing it to the boys with a poverty income ratio greater than or equal to one. Boys (33%) who smoked were in the highest quartile for factor 1, compared to 25% who reported being a non-smoker and 18% of boys who possibly smoked in the highest quartile of factor 1.

Boys in the highest quartile of factor 1 reported moderate physical activity (43.26%) during the past month. 38% of boys in the highest quartile for factor 1 reported being inactive during the past month. 32% of boys in the highest quartile for factor 1 reported watching television for 4-5 hours the day before the interview, compared to 31% of boys in the lowest quartile who reported watching only 0-1 hours of television the day before the interview.

Factor 2 – Total Sample for Boys

In Table 4.34 we also reported the demographic characteristics of the factor loading scores on factor 2 in boys 12-19 years old. Factor 2 loaded high on total cholesterol levels and LDL-cholesterol levels and was similar to factor 2 in the overall

sample. The percentage of boys in the highest quartile of factor 2 seemed to be approximately equally distributed among all age groups. However, boys 14-15 years and 16-17 years had the highest percentages in the lowest quartile of factor 2. Older boys 18-19 years old had the highest percentage (25.55%) on the fourth quartile of factor 2 (12-13 (23.81%), 14-15 (17.52 %), 16-17 (18.12%)).

Boys in Tanner stage 1 (41.19%) and Tanner stage 2 (41.40%) had very high percentages in the highest quartile of factor 2, compared to boys in Tanner stage 3 (14.54%), Tanner stage 4 (14.78 %) and Tanner stage 5 (23.51 %). 41% of boys in Tanner stage 4 were in the lowest quartile of factor 2.

Non-Hispanic black boys (29.90%) had the highest percentage in the top quartile of factor 2 compared to the other race/ethnic groups (non-Hispanic white (21.05 %) and Mexican American (23.21) and Other (6.81%)) and non-Hispanic white boys had the highest percentage in the lowest quartile of factor 2.

Boys with a poverty income ratio less than one were more likely to be in the highest quartile of factor 2, whereas boys with a poverty income ratio greater than and equal to one and less than 2, were more likely to be in the lowest quartile of factor 2, followed by boys with a poverty income ratio greater than two. 29% of boys in the highest quartile of factor 2 reported smoking. Only 19% in the highest quartile of factor 2 reported non-smoking.

Boys in the highest quartile of factor 2 also reported moderate physical activity during the past month, where as 75% of boys in the lowest quartile of factor 2 reported being inactive during the past month. There were no big differences in the percentage of

hours of television watching in the highest quartile of factor 2. However, 34% in the lowest quartile of factor 2 reported watching 4-5 hours per week.

Factor 3-Total Sample for Boys

Factor 4.34, which is also presented in Table 12, loaded positive on LDL-cholesterol and HDL-cholesterol. Boys in the highest quartile of factor 3 were more likely to be between the ages of 18-19 years old (33.96 %), and boys in the lowest quartile of factor 3 were more likely to be 16-17 years old (37.31%). There were no substantial differences among boys within Tanner stage at the highest quartile of factor 3. The majority of boys in Tanner stage 2 (57.39%), Tanner stage 3 (34.28 %) and Tanner stage 4 (33.36 %) were more likely to be in the lowest quartile of factor 3.

Similar findings as in factor 2 were seen in factor 3, in that non-Hispanic black boys were more likely to be in the highest quartile of factor 3 (28.52%), and non-Hispanic white boys were more likely to be in the lowest quartile of factor 3 (32.59 %). The majority of boys with a poverty income ratio less than one were in the lowest two quartiles of factor 3. 27% of boys with a poverty income ratio less than one were in the highest quartile of factor 3 compared to 27.40% with a poverty income ratio greater than and equal to one, and less than two, and a poverty income ratio greater than and equal to two (22.50%). However, there were no significant differences within poverty income ratio among quartiles in factor 3.

Differences with regards to smoking status were also non-significant among quartiles in factor 3. Boys who reported possibly smoking had the highest percentage in the fourth quartile of factor 3. Similar results as in factor 1 and factor 2 were found for factor 3 in terms of physical activity. Boys in the highest quartile of factor 3 reported

moderate physical activity levels during the past month. Boys in the highest quartile of factor 3 were more likely to watch television for more than 5 hours a day. Boys who only watched television for 1 hour or less were more likely to be in the lowest quartile of factor 3.

Summary of Factor 1, Factor 2 and Factor 3 - Boys

In summary, boys who loaded high on factor 1, which is the most closely related to metabolic syndrome, were more likely to be older (18-19 years old), Mexican American and have a poverty income ratio of less than one. They were also more likely to be categorized as smokers, reported moderate physical activity levels and watched between 4-5 hours of television per day. Factor 1 in this sample presented 28% of the variance explained all three factors combined presented 61% of the variance explained.

Factor 2 and factor 3 in boys 12-19 years old were similar, in that both of them loaded high on total cholesterol and LDL-cholesterol, but factor 3 also loaded high and positively on HDL-cholesterol. Boys who were high in these two factors were more likely to be older (18-19 years old), and non-Hispanic black. Boys in factor 2 were more likely to be smokers and reported moderate physical activity. Factor 3 also reported moderate physical activity levels, and reported that they watched more than 5 hours of television per day.

Factor 1 – Total Sample for Girls

We analyzed these data to include all girls 12-19 years since stratified by age and Tanner stage did not yield interpretable results (Table 4.35). Factors that were produced from this sample were not as clearly interpretable as the overall sample and the total sample in boys 12-19 years. Girls in factor 1 had high levels of LDL-cholesterol and total

cholesterol and this factor was similar to factor 2 in boys. Girls in the highest quartile of factor 1 were more likely to be older (18-19 years old) (12-13 (20.06%), 14-15 (19.91%), 16-17 (24.98%), 18-19 (30.02%) and girls in the lowest quartile of factor 1 were more likely to be between 16 and 17 years old (33.47 % vs. (12-13 (25.98%), 14-15 (27.77%), 18-19 (17.55%)). Girls in the highest quartile of factor 1 were also more likely to be at Tanner stage 2 in terms of sexual maturation.

Findings in girls were similar to findings in boys who had high values of LDL-cholesterol and total cholesterol. Girls who were non-Hispanic black were more likely to be in the highest quartile of factor 1 (29.14 %) compared to non-Hispanic white (22.67%), and Mexican American (19.22 %) girls. In contrast to boys, girls in the highest quartile of factor 1 were more likely to have a poverty income ratio greater than and equal to two. Girls in the lowest quartile of factor 1 were also more likely to have a poverty income ratio greater than and equal to two. Girls in the highest quartile of factor 1 were more likely to smoke and report moderate physical activity levels in the past month. Thirty two percent (32%) of girls in the lowest quartile of factor 1 reported no physical activity during the past month. One third of girls in the lowest quartile of factor 1 reported that they watched more than 5 hours of television per day, whereas 26% in the highest quartile reported watching television 4-5 hours per day.

Factor 2 – Total Sample for Girls

In Table 4.35, the demographic characteristics of the factor loading scores for girls in Factor 2 are presented. In the highest quartile of factor 2 for girls, there were no big differences in the percentage distribution of age. Girls in the lowest quartile were more likely to be younger (12-13 years (40.46%) and 14-15 years (30.58%)). There were

also 28% of 18-19 year old girls in the lowest quartile of factor 2. We found an equal distribution of girls in Tanner stage one in the lowest (54%) and the highest quartiles (40.18%). The majority of girls were in the lowest quartile of factor 2 within Tanner stage, especially Tanner stage 3 and Tanner stage 4. Among the highest quartile in factor 2, race/ethnic groups were equally distributed. However, among the lowest quartile there were 30.94% non-Hispanic white and girls, 24.46% non-Hispanic girls, 19.22 Mexican American girls and 28% girls from other race/ethnic groups.

Girls in the highest quartile of factor 2 were more likely to have a poverty income ratio of less than one and girls in the lowest quartile were more likely to have a poverty income ratio greater than two. Girls in the highest quartile of factor 2 were classified as smokers and 54% reported being inactive during the past month. Also among girls in the highest category, 29% reported watching television 4-5 hours the day before the interview, whereas 20% reported watching television for less than 1 hour the day before the interview

Factor 3 – Total Sample Girls

Girls in factor 3 (Table 4.35) had higher levels of glucose, systolic blood pressure and diastolic blood pressure. Age was evenly distributed among girls in the highest and lowest quartile of factor 3. The majority of girls in the highest quartile of factor 3 were in Tanner stage 3 (25.74 %), Tanner stage 4 (23.66%) and Tanner stage 5 (23.87%), and only a very small percentage was in Tanner stage 1 and Tanner stage 2.

There were no significant differences among race/ethnic groups within quartiles of factor 3, although non-Hispanic blacks were the most prevalent in quartile 4 compared to other race/ethnic groups (non-Hispanic white (22.75%), non-Hispanic black (27.31%),

and Mexican American (25.05%)). There were also no significant differences seen in poverty income ratio among quartiles of factor 3 in girls.

Girls in the highest quartile of factor 3 were more likely to be categorized as non-smokers, whereas girls in the lowest quartile were more likely to be categorized as smokers. An interesting finding was that girls in the highest quartile of factor 3, were more likely to report a vigorous physical activity level during the past month, and were less likely to watch television. Whereas girls in the lowest quartile reported watching 2-3 hours of television the day before the interview.

Factor 4 – Total Sample for Girls

Girls in factor 4 had high levels of triglycerides and glucose and low levels of HDL-cholesterol and systolic blood pressure percentiles. Similar results as in factor 3 were found in factor 4, in that girls had similar age distributions in the highest quartile, and in the lowest quartile of factor 4 girls tend to be older than (12-13 (16.04%), 14-15 (19.95%), 16-17 (22.49%), 18-19 (28.98%)). Girls in the highest quartile of factor 4 were more likely to be at Tanner stage 1 and Tanner stage 3. Girls in the lowest quartile were more likely to be at Tanner stage 1.

There were more non-Hispanic white (30.43%) and Mexican American (27.80%) girls in the highest quartile of factor 4 (vs. non-Hispanic black (12.54%)), and more non-Hispanic black girls in the lowest quartile of factor 4. Within poverty income ratio, no substantial differences were found among quartiles in factor 4. Girls in the highest quartile of factor 4 were also more likely to be smokers and reported being inactive during the past month. Whereas girls in the lowest quartile most likely reported having

vigorous activity levels during the past month. Girls in the highest quartile of factor 4, watched between 2 and 5 hours of television the day before the interview.

Summary of Factor 1, Factor 2, Factor 3 and Factor 4 -Girls

In summary, girls 12-19 years old had a different factor loading pattern compared to boys. There was no clear pattern of metabolic syndrome among girls in the total sample, but each factor did produce interesting results when compared to demographic factors. The four factors in the total sample for girls presented 72% of the variance explained.

Girls in factor 1 with high LDL-cholesterol and high total cholesterol levels were more likely to be older (18-19 years) and non-Hispanic black. It is notable that girls in the highest quartile of factor 1 appeared to have a higher poverty income ratio compared to other adolescent girls. However, they were also more likely to be categorized as smokers and watched 4-5 hours of television per day.

Girls in factor 2 who were classified as being overweight or at risk for overweight with high waist circumference levels were more likely to have a poverty income ratio less than one. They were classified as smokers, being inactive and watched television for 4-5 hours per day. Among the girls in factor 2 there were no significant differences in age or race/ethnic group.

Girls in factor 3 had high levels of glucose, systolic blood pressure and diastolic blood pressure. They were more likely to have elevated levels at Tanner stage 3, Tanner stage 4 and Tanner stage 5 and be classified as non-smokers, with vigorous physical activity levels and watch television for less than one hour per day.

Factor 4 loaded high on triglycerides and glucose and low on HDL-cholesterol. Girls with high scores on factor 4 were more likely to be non-Hispanic white and Mexican American. They were also classified as smokers, being inactive and watched television the day before the interview for 2 to 5 hours.

Table 4.1 Select Characteristics of Total Adolescent Study Population (12-19 years) who fasted for 6 hours or more, by Gender

Characteristic	Boys (n=1142)			Girls (n=1181)		
	N	Total % [†]	SE	N	Total % [†]	SE
Age at Interview (Years)[#]						
12	158	14.18	1.52	146	10.37	1.12
13	161	14.00	1.69	171	12.96	1.01
14	135	11.93	1.44	163	15.68	1.91
15	145	10.99	1.28	131	12.41	1.13
16	144	12.80	1.33	179	13.62	1.72
17	140	13.42	1.39	144	12.28	1.31
18	128	10.06	1.17	124	11.41	1.16
19	131	12.63	1.62	123	11.28	2.01
Tanner stage at Interview (pubic hair)						
1	76	6.88	1.32	7	0.94	0.44
2	57	4.39	1.00	39	3.85	0.86
3	110	9.97	1.40	95	7.31	1.23
4	211	25.11	2.36	356	35.15	2.57
5	574	53.66	3.07	537	52.75	2.65
Missing	114	10.84	3.34	147	13.51	2.41
Race/Ethnicity[#]						
Non-Hispanic White	290	68.49	2.53	322	63.28	3.20
Non-Hispanic Black	388	14.42	1.26	405	16.06	1.74
Mexican American	420	8.48	0.96	388	8.79	1.10
Other	44	8.61	2.09	66	11.86	2.34
Poverty Income Ratio						
< 1	382	18.27	1.67	379	22.08	2.27
≥1 and < 2	294	21.76	1.97	302	22.68	2.41
≥ 2	348	49.42	2.42	395	49.32	2.66
Missing	118	10.56	1.84	105	5.92	1.30
Hours of TV watched yesterday (12-16 years)[#]						
0-1	179	27.91	3.32	198	33.89	3.18
2-3	240	33.59	2.80	272	32.17	2.76
4-5	276	31.17	2.88	278	27.64	3.22
>5	48	7.34	1.72	42	6.30	1.32
Physical activity level (17-19 years)						
Inactive	19	4.42	1.56	51	10.45	2.07
Moderate	122	32.00	3.31	195	44.53	5.02
Vigorous	250	62.18	3.73	138	43.01	5.18
Missing	8	1.40	0.70	7	2.01	0.94
Smoking Status^{* #}						
Smoking	135	15.21	1.92	85	12.27	1.67
Not Smoking	966	80.98	1.96	1064	84.11	1.95
Possibly Smoking	41	3.82	0.82	32	3.62	0.87

* Smoking Status: Smoking: Self-reported tobacco use and cotinine levels > 15ng/mL; Not Smoking: Self-reported non-tobacco user and cotinine levels ≤ 15 ng/mL; Possibly Smoking: Self-reported non-tobacco user and cotinine levels > 15ng/mL; † Column percents add to 100; # No missing values

Table 4.2 BMI-for-Age percentiles[†] among US Adolescents (12-19 years old) by Age, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994.

Population	Boys					Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Age (years)										
12-13	314	59.29 (1.90)	13.36	60.04	95.65	309	59.74 (3.11)	14.18	63.29	96.55
14-15	275	59.19 (3.09)	16.05	60.77	93.42	287	61.91 (2.53)	23.27	61.94	95.16
16-17	283	58.75 (2.76)	17.47	61.54	97.07	318	61.95 (2.42)	25.16	60.96	94.99
18-19	259	49.68 (4.03)	10.22	48.76	95.81	246	53.92 (3.12)	4.41	57.86	94.84
Race/ethnicity and Age (years)										
Non-Hispanic White										
12-13	81	60.20 (2.75)	13.14	60.12	94.63	73	60.90 (4.13)	19.37	60.84	96.64
14-15	64	62.29 (4.44)	15.58	69.48	91.65	93	59.28 (3.37)	22.79	58.98	94.96
16-17	79	59.84 (3.27)	18.86	61.87	97.51	79	58.27 (3.32)	20.77	55.79	91.11
18-19	64	50.49 (5.75)	9.42	48.20	96.15	73	52.58 (4.18)	8.23	54.93	94.83
Non-Hispanic Black										
12-13	103	57.62 (2.70)	10.95	54.76	97.07	108	65.36 (3.50)	10.37	72.00	96.68
14-15	106	58.45 (3.07)	17.57	59.94	93.42	86	68.14 (3.65)	17.96	76.23	98.32
16-17	90	58.37 (4.29)	12.45	63.14	93.95	113	68.58 (2.43)	21.16	73.81	97.57
18-19	87	52.75 (4.72)	6.68	51.82	96.67	91	58.50 (3.05)	8.21	64.80	97.34
Mexican American										
12-13	119	64.26 (2.02)	15.18	69.79	97.72	113	68.04 (3.02)	17.10	72.25	97.16
14-15	94	59.29 (2.44)	18.76	60.45	96.88	93	69.65 (3.21)	26.31	76.06	96.74
16-17	104	63.14 (2.22)	15.87	69.31	94.78	102	65.50 (2.79)	26.89	72.38	97.00
18-19	96	60.45 (4.08)	13.96	65.61	97.32	71	62.60 (3.94)	25.43	61.57	94.61

Table 4.2 BMI-for-Age percentiles among US Adolescents (12-19 years old) by Age, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994 (cont'd)

Population	Boys					Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Poverty Income Ratio [†] and Age										
< 1										
12-13	143	62.82 (3.37)	23.15	58.80	95.23	125	66.28 (3.88)	21.09	73.12	97.29
14-15	115	51.75 (5.25)	15.39	47.74	95.13	104	65.50 (4.74)	33.15	62.15	95.48
16-17	118	55.98 (4.89)	14.07	54.69	96.75	130	72.39 (3.68)	37.57	82.95	97.27
18-19	120	54.57 (6.60)	11.01	55.22	96.47	114	58.66 (4.07)	12.59	66.11	95.67
≥ 1 and < 2										
12-13	71	62.29 (5.77)	19.27	59.59	96.79	82	65.45 (5.46)	17.26	72.79	97.39
14-15	76	64.09 (4.10)	17.09	72.07	97.32	75	63.50 (5.93)	14.69	66.43	97.43
16-17	79	53.80 (4.60)	17.49	50.65	97.87	84	58.77 (4.18)	11.87	59.38	93.98
18-19	65	54.48 (6.12)	9.35	51.87	95.09	59	48.81 (7.43)	1.89	53.56	95.15
≥ 2										
12-13	100	56.36 (3.44)	10.00	58.36	93.59	102	54.29 (4.68)	10.16	48.69	92.77
14-15	84	61.55 (4.65)	23.50	67.34	89.77	108	59.68 (3.53)	23.40	60.41	94.71
16-17	86	61.90 (3.33)	20.51	65.44	96.28	104	57.37 (3.53)	22.44	55.50	87.50
18-19	74	43.46 (3.48)	3.72	38.01	82.63	73	52.52 (4.26)	9.37	52.77	94.54

[†] BMI-for-Age Percentiles calculated from the CDC growth charts developed by National Center for Health Statistics : Between 85th and 95th – At risk for Overweight; > 95th percentile - Overweight

[‡] Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

Table 4.3 Waist Circumference (cm) Distribution among US Adolescents (12-19 years old) by Age, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994.

Population	Boys				Girls					
	N	Mean (SE)	Percentiles		N	Mean (SE)	Percentiles			
			10	50	90		10	50	90	
Age (years)										
12-13	311	72.60 (0.75)	60.28	69.61	86.51	309	71.71 (1.08)	60.77	68.39	85.20
14-15	272	76.51 (1.03)	66.31	72.99	91.48	286	76.03 (1.03)	63.93	73.52	91.80
16-17	278	80.30 (0.88)	70.37	77.38	97.23	313	78.27 (1.07)	66.75	75.57	93.73
18-19	252	81.77 (1.49)	71.01	78.53	101.63	245	78.02 (1.24)	65.00	74.62	93.69
Race/ethnicity and Age (years)										
Non-Hispanic White										
12-13	79	72.84 (1.00)	60.51	70.95	85.99	75	72.18 (1.54)	61.87	68.35	86.27
14-15	63	77.96 (1.47)	67.22	74.83	90.65	91	74.81 (1.37)	63.87	72.52	89.53
16-17	77	80.49 (1.13)	71.03	77.41	97.88	76	77.87 (1.65)	66.92	73.47	89.33
18-19	61	82.88 (2.21)	71.24	79.47	101.38	73	77.90 (1.76)	66.26	73.92	93.77
Non-Hispanic Black										
12-13	103	72.11 (1.03)	58.55	65.95	92.16	108	72.86 (1.27)	60.82	69.44	86.78
14-15	105	74.32 (1.32)	62.52	70.98	86.32	86	79.47 (2.87)	63.19	74.71	99.91
16-17	90	76.10 (1.50)	66.24	72.92	87.86	113	79.22 (0.95)	65.01	75.59	98.80
18-19	85	78.99 (1.81)	67.75	75.90	92.59	89	81.94 (1.62)	64.71	76.42	106.85
Mexican American										
12-13	118	75.59 (1.00)	61.10	71.83	95.35	111	74.03 (1.32)	61.74	72.38	88.68
14-15	93	77.97 (0.95)	65.65	73.64	91.76	94	76.90 (0.93)	65.00	73.51	91.71
16-17	102	81.62 (0.85)	68.78	80.91	96.88	101	78.78 (1.38)	65.41	76.17	93.82
18-19	95	84.43 (1.71)	71.47	91.55	101.17	72	78.37 (0.89)	66.68	76.42	90.30

Table 4.3 Waist Circumference (cm) Distribution among US Adolescents (12-19 years old) by Age, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994 (cont'd)

Population	Boys				Girls					
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Poverty Income Ratio [†] and Age										
< 1										
12-13	142	73.53 (1.08)	61.08	71.85	89.03	125	73.64 (1.46)	61.71	70.47	91.17
14-15	113	74.96 (1.75)	64.69	70.90	88.89	105	79.31 (3.08)	65.60	74.06	101.08
16-17	114	80.40 (1.48)	69.32	77.52	95.95	128	83.44 (2.49)	69.17	78.58	105.01
18-19	118	83.90 (2.48)	71.58	78.47	101.87	113	80.60 (2.01)	67.36	75.04	110.02
≥ 1 and < 2										
12-13	71	73.18 (1.72)	60.41	69.12	85.37	82	74.55 (2.56)	60.87	72.38	96.69
14-15	75	78.44 (1.25)	67.20	75.30	94.04	75	77.58 (1.95)	64.87	75.58	91.80
16-17	78	78.35 (1.77)	67.95	73.63	95.62	82	77.48 (1.53)	65.09	77.23	89.56
18-19	62	83.07 (2.17)	70.92	81.16	98.09	59	76.74 (2.52)	--	72.80	94.27
≥ 2										
12-13	98	71.91 (1.17)	60.01	69.30	86.13	102	69.64 (1.23)	59.71	67.30	80.81
14-15	84	76.54 (1.61)	64.89	73.59	90.40	106	73.85 (1.26)	63.28	72.41	88.81
16-17	86	80.95 (1.26)	70.85	77.74	98.26	103	75.57 (1.19)	66.73	72.68	86.84
18-19	72	79.46 (1.42)	68.91	77.23	89.23	73	76.58 (1.37)	66.80	74.15	87.75

[†] Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

Table 4.4 Triglyceride Level (mg/dL) Distribution among US Adolescents (12-19 years old by Age, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994.

Population	Boys				Girls					
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Age (years)										
12-13	302	90.54 (3.45)	44.62	79.84	138.04	297	85.44 (4.68)	47.04	72.53	136.64
14-15	260	82.52 (4.17)	43.58	72.30	117.86	279	87.29 (3.69)	47.78	75.63	133.53
16-17	270	98.61 (12.51)	41.81	79.69	158.64	307	83.57 (3.59)	45.76	71.32	132.37
18-19	250	105.40 (6.36)	53.33	88.06	187.29	237	92.35 (6.89)	44.65	72.22	165.31
Race/ethnicity and Age (years)										
Non-Hispanic White										
12-13	82	90.80 (4.89)	44.27	80.81	146.82	70	91.15 (6.29)	47.20	77.01	139.39
14-15	56	85.60 (6.34)	41.63	74.99	115.75	86	91.50 (5.28)	46.3	84.31	153.09
16-17	76	106.17 (16.97)	48.15	85.74	163.29	77	86.21 (5.33)	46.26	78.14	145.88
18-19	63	110.47 (9.02)	55.07	90.29	188.86	70	93.10 (9.54)	43.55	72.42	146.51
Non-Hispanic Black										
12-13	93	84.31 (10.06)	41.24	64.45	110.65	102	71.24 (3.52)	41.29	63.80	96.38
14-15	101	73.78 (4.22)	41.78	67.71	114.61	81	72.17 (4.80)	38.73	69.66	95.11
16-17	85	75.56 (3.47)	36.64	68.25	104.80	113	65.74 (2.87)	38.05	57.33	96.61
18-19	81	78.26 (5.27)	43.23	64.36	119.22	85	78.21 (4.17)	46.32	68.61	112.57
Mexican American										
12-13	116	86.65 (3.94)	42.80	74.31	134.96	110	89.83 (5.10)	47.36	81.38	134.11
14-15	92	91.90 (6.59)	42.33	76.64	143.55	96	86.24 (2.16)	52.97	77.99	124.79
16-17	100	103.80 (7.64)	49.40	80.76	189.08	95	93.80 (7.31)	47.72	76.47	160.53
18-19	94	102.87 (10.78)	49.18	89.03	153.70	71	91.64 (5.87)	51.05	81.26	142.61

Table 4.4 Triglyceride Level (mg/dL) Distribution among US Adolescents (12-19 years old) by Age, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994 (cont'd)

Population	N	Mean (SE)	Boys			N	Mean (SE)	Girls		
			Percentiles					Percentiles		
			10	50	90			10	50	90
Poverty Income Ratio ^a and Age										
< 1										
12-13	138	85.69 (4.81)	48.21	72.29	133.44	120	81.64 (4.65)	46.49	71.79	113.66
14-15	111	88.76 (12.37)	47.85	70.92	110.99	104	87.54 (6.69)	48.94	76.51	140.03
16-17	113	93.13 (10.78)	41.79	81.33	191.48	124	90.75 (7.43)	46.57	71.74	146.20
18-19	115	120.99 (10.91)	56.69	103.36	198.76	109	83.06 (7.67)	43.32	69.84	142.71
≥ 1 and < 2										
12-13	71	107.10 (10.79)	41.00	88.53	152.45	81	79.17 (6.40)	40.71	68.50	135.31
14-15	75	80.32 (5.52)	42.27	70.68	129.21	69	80.57 (5.80)	51.81	69.18	127.37
16-17	73	98.14 (11.23)	39.46	78.35	157.38	81	83.88 (6.57)	48.14	78.29	128.11
18-19	64	101.81 (7.14)	51.33	92.36	150.29	57	91.37 (22.77)	43.06	63.70	113.85
≥ 2										
12-13	93	85.13 (4.89)	44.11	79.08	128.63	96	89.58 (6.86)	50.10	72.92	141.80
14-15	74	79.22 (4.67)	41.75	72.30	121.17	106	89.87 (6.03)	38.97	76.69	162.81
16-17	84	101.28 (19.41)	43.55	78.87	142.18	102	79.01 (3.91)	44.66	64.53	129.64
18-19	71	93.93 (8.33)	52.77	70.12	157.55	71	100.14 (8.09)	47.18	74.81	181.21

† Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

Table 4.5 Total Cholesterol Level (mg/dL) Distribution among US Adolescents (12-19 years old) by Age, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994.

Population	Boys					Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Age (years)										
12-13	302	161.59 (2.68)	122.10	162.19	197.26	298	163.97 (2.31)	127.63	160.13	200.88
14-15	262	154.74 (2.29)	124.55	150.03	184.93	279	164.14 (2.88)	128.18	160.70	197.49
16-17	271	155.62 (2.59)	118.81	151.95	198.78	307	160.47 (2.20)	118.69	155.37	200.05
18-19	250	164.61 (3.22)	126.11	158.44	209.38	237	171.95 (3.51)	133.51	169.43	215.76
Race/ethnicity and Age (years)										
Non-Hispanic White										
12-13	82	158.71 (3.48)	118.05	157.75	192.63	70	163.56 (3.85)	126.59	158.99	199.31
14-15	57	153.26 (3.58)	123.02	148.27	181.66	86	163.41 (3.14)	129.21	161.23	193.51
16-17	77	153.86 (2.63)	118.03	151.28	195.93	77	158.59 (3.54)	116.29	152.10	197.35
18-19	63	164.16 (4.58)	121.25	155.04	206.74	70	167.20 (3.38)	127.74	166.09	198.13
Non-Hispanic Black										
12-13	93	177.24 (4.09)	137.56	174.50	212.11	103	171.68 (2.88)	127.00	169.67	214.53
14-15	101	162.12 (2.43)	123.45	161.28	195.98	81	169.77 (3.95)	125.68	163.70	217.74
16-17	85	163.38 (3.50)	126.37	159.38	194.39	113	165.62 (2.54)	129.21	158.87	212.29
18-19	81	168.17 (3.48)	135.26	160.27	214.27	85	176.76 (6.44)	132.37	172.07	218.99
Mexican American										
12-13	116	159.72 (2.58)	125.01	156.93	196.05	110	159.00 (4.25)	121.33	156.90	191.14
14-15	93	154.62 (3.19)	119.64	151.19	195.95	96	158.42 (1.81)	127.84	154.59	192.24
16-17	100	162.26 (4.23)	125.92	155.14	201.88	95	165.32 (3.59)	125.69	159.77	212.20
18-19	94	169.75 (3.70)	137.00	164.31	208.46	71	171.10 (5.47)	129.53	163.52	214.23

Table 4.5 Total Cholesterol Level (mg/dL) Distribution among US Adolescents (12-19 years old) by Age, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994 (cont'd)

Population	N	Mean (SE)	Boys			N	Mean (SE)	Girls		
			10	50	90			10	50	90
Poverty Income Ratio [†] and Age										
<1										
12-13	138	169.18 (5.15)	137.04	164.26	210.94	121	163.73 (3.04)	122.16	165.24	192.95
14-15	111	156.46 (4.90)	117.95	162.02	183.78	104	168.68 (5.53)	126.10	162.47	221.14
16-17	113	161.70 (6.08)	125.15	160.43	205.10	124	164.37 (3.96)	136.12	155.77	202.89
18-19	115	170.04 (7.06)	122.10	165.49	216.11	109	170.16 (6.19)	134.81	164.77	224.42
≥ 1 and < 2										
12-13	71	154.05 (3.99)	117.33	154.09	189.49	81	163.93 (3.27)	129.79	162.29	199.30
14-15	75	158.68 (5.12)	123.66	157.69	197.12	69	158.07 (3.03)	133.44	157.09	181.06
16-17	73	161.44 (4.85)	128.42	156.28	195.54	81	165.20 (3.27)	133.06	163.12	197.34
18-19	64	156.63 (4.66)	118.62	152.87	187.39	57	161.23 (5.55)	126.02	155.92	189.38
≥ 2										
12-13	93	161.66 (4.32)	129.07	162.64	193.79	96	164.10 (3.49)	126.96	158.34	201.34
14-15	76	151.40 (2.69)	127.04	146.95	178.87	106	164.55 (3.47)	128.06	161.46	195.99
16-17	85	150.89 (2.77)	117.45	148.03	198.28	102	155.63 (4.10)	115.15	146.70	197.84
18-19	71	163.46 (3.24)	132.36	155.86	198.22	71	178.34 (5.36)	139.01	176.42	218.97

† Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

Table 4.6 HDL-Cholesterol Level (mg/dL) Distribution among US Adolescents (12-19 years old) by Age, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994.

Population	Boys					Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Age (years)										
12-13	301	49.82 (1.03)	35.44	47.76	63.71	297	51.82 (1.18)	38.27	51.37	64.17
14-15	258	47.59 (1.07)	35.22	45.92	61.62	277	51.73 (1.12)	35.80	50.34	69.23
16-17	269	45.87 (1.30)	31.79	44.11	61.93	306	50.80 (0.79)	36.22	51.58	62.13
18-19	249	46.68 (0.96)	34.07	44.79	62.35	234	53.49 (1.21)	38.21	52.02	66.79
Race/ethnicity and Age (years)										
Non-Hispanic White										
12-13	81	48.18 (1.23)	34.18	45.85	61.54	70	49.83 (1.50)	37.72	48.45	60.89
14-15	56	45.51 (1.49)	33.37	43.51	58.61	86	50.68 (1.47)	34.84	48.98	68.98
16-17	76	44.20 (1.29)	30.94	42.48	55.97	77	49.54 (1.07)	36.17	51.43	60.19
18-19	63	44.79 (1.32)	33.65	42.91	57.17	69	52.93 (1.92)	34.20	52.12	66.67
Non-Hispanic Black										
12-13	93	56.91 (1.43)	41.17	55.73	72.73	103	55.76 (1.29)	40.15	53.55	75.24
14-15	100	53.81 (1.45)	38.87	51.53	69.50	79	55.71 (1.95)	38.30	55.25	70.96
16-17	84	51.08 (1.23)	37.19	49.79	66.56	113	54.27 (1.48)	40.24	52.90	70.72
18-19	80	50.77 (1.35)	36.45	49.26	65.50	83	55.24 (1.41)	42.08	50.96	69.77
Mexican American										
12-13	116	51.15 (1.03)	33.15	50.80	66.89	109	51.18 (1.50)	38.47	50.23	61.82
14-15	91	46.82 (1.19)	34.20	45.52	59.32	96	50.95 (1.17)	33.99	50.20	64.96
16-17	100	46.87 (1.08)	35.05	46.37	59.47	94	52.11 (1.19)	37.02	52.57	65.85
18-19	94	49.41 (1.50)	35.11	47.40	61.91	71	52.93 (1.50)	39.09	50.10	68.13

Table 4.6 HDL-Cholesterol Level (mg/dL) Distribution among US Adolescents (12-19 years old) by Age, Within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994 (cont'd)

Population	N	Mean (SE)	Boys			N	Mean (SE)	Girls		
			10	50	90			10	50	90
Poverty Income Ratio [†] and Age										
< 1										
12-13	138	52.63 (2.01)	37.20	48.24	69.89	120	51.56 (1.28)	36.54	48.86	69.48
14-15	111	49.17 (2.05)	32.95	49.46	63.87	103	51.87 (1.81)	65.73	50.66	68.83
16-17	112	45.97 (1.92)	35.14	44.05	60.73	124	50.26 (2.12)	33.37	51.88	61.85
18-19	114	46.68 (1.89)	35.08	43.78	61.72	108	52.04 (2.19)	34.37	50.29	66.20
≥ 1 and < 2										
12-13	71	48.71 (1.97)	33.59	47.63	60.14	81	52.84 (1.61)	40.12	53.43	62.76
14-15	74	49.01 (1.90)	36.51	47.55	61.76	68	50.73 (1.10)	40.95	50.04	60.89
16-17	73	47.38 (1.78)	35.20	46.62	61.89	81	51.51 (1.97)	38.25	52.30	63.70
18-19	64	47.09 (2.34)	32.63	45.79	61.47	56	55.28 (1.65)	39.67	55.34	65.64
≥ 2										
12-13	92	49.08 (1.30)	35.36	47.65	62.11	96	51.53 (1.67)	38.30	50.30	63.25
14-15	73	45.68 (1.45)	34.39	43.11	57.50	106	52.06 (1.82)	34.53	50.37	69.65
16-17	84	45.30 (1.99)	30.94	41.96	62.12	101	50.76 (1.11)	36.35	51.47	61.84
18-19	71	46.50 (1.74)	34.05	45.32	62.90	70	53.83 (1.63)	34.81	52.69	70.06

[†] Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

Table 4.7 LDL-Cholesterol Level (mg/dL) Distribution among US Adolescents (12-19 years old) by Age, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994

Population	Boys				Girls					
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Age (years)										
12-13	298	93.94 (2.42)	60.81	94.37	124.20	296	95.03 (2.25)	68.61	89.87	127.53
14-15	257	90.52 (1.98)	61.57	88.66	118.36	277	94.86 (2.74)	65.47	91.01	130.10
16-17	268	90.86 (2.82)	58.73	86.60	133.41	306	92.97 (2.17)	53.65	89.02	129.98
18-19	248	96.74 (2.81)	68.25	92.54	139.80	234	100.71 (3.46)	60.95	99.04	139.64
Race/ethnicity and Age (years)										
Non-Hispanic White										
12-13	81	92.63 (3.21)	57.47	94.06	121.81	70	94.49 (3.63)	68.83	90.81	127.60
14-15	55	90.51 (2.99)	62.27	86.17	116.56	86	94.42 (3.23)	62.82	91.72	128.24
16-17	75	89.64 (2.97)	60.45	82.25	132.31	77	91.81 (3.40)	47.80	87.33	129.96
18-19	63	97.27 (4.07)	64.00	92.85	139.31	69	96.85 (3.88)	59.68	95.80	132.18
Non-Hispanic Black										
12-13	91	104.27 (3.43)	68.98	100.45	137.54	102	101.57 (2.72)	66.93	99.42	140.37
14-15	100	93.16 (3.02)	54.71	92.60	125.25	79	98.99 (2.93)	72.67	94.41	136.01
16-17	84	97.33 (3.21)	60.73	96.50	123.82	113	98.20 (2.41)	67.98	92.88	135.10
18-19	80	100.91 (3.05)	72.78	95.85	132.51	83	105.42 (5.54)	69.86	100.57	149.81
Mexican American										
12-13	115	91.39 (2.58)	64.77	87.35	124.07	109	89.79 (4.70)	52.87	86.80	118.02
14-15	91	89.62 (2.68)	61.56	85.97	120.21	96	90.21 (1.83)	61.99	85.37	121.32
16-17	100	94.61 (3.44)	62.05	91.91	128.23	94	94.69 (3.21)	62.11	88.39	130.13
18-19	93	100.11 (3.29)	66.99	99.34	137.45	71	99.83 (5.37)	59.76	96.51	139.64

Table 4.7 LDL-Cholesterol Level (mg/dL) Distribution among US Adolescents (12-19 years old) by Age, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994 (cont'd)

Population	Boys					Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Poverty Income Ratio [†] and Age										
< 1										
12-13	137	99.48 (4.45)	73.75	93.17	135.79	119	95.70 (3.27)	66.94	96.05	120.87
14-15	110	90.56 (4.24)	53.80	86.58	116.38	103	99.11 (4.35)	72.22	86.82	142.72
16-17	112	96.82 (5.70)	61.99	87.97	148.54	124	95.96 (4.05)	63.55	94.31	129.97
18-19	113	98.90 (5.86)	62.33	94.07	139.04	108	101.30 (5.02)	66.67	98.57	157.66
≥ 1 and < 2										
12-13	69	84.04 (3.72)	54.08	80.41	110.43	81	95.25 (3.31)	66.22	89.25	129.42
14-15	74	93.31 (4.94)	66.40	88.52	135.58	68	90.99 (2.73)	73.44	86.63	111.82
16-17	73	94.43 (4.73)	68.51	87.99	129.64	81	96.91 (3.85)	60.94	96.82	130.00
18-19	64	89.17 (3.31)	61.05	86.14	113.21	56	91.34 (5.15)	57.63	94.52	114.80
≥ 2										
12-13	92	95.95 (4.11)	63.29	98.58	129.85	96	94.65 (3.45)	68.97	88.85	127.19
14-15	73	88.96 (2.61)	61.24	88.81	116.73	106	94.51 (3.39)	58.34	92.93	130.79
16-17	83	86.81 (3.45)	57.42	83.24	123.94	101	89.09 (3.94)	47.07	84.56	129.65
18-19	71	98.17 (2.96)	71.64	92.09	136.08	70	104.43 (5.43)	59.44	99.58	143.73

[†] Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

Table 4.8 Glucose Level Distribution (mg/dL) among US Adolescents (12-19 years old) by Age, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994.

Population	Boys				Girls					
	N	Mean (SE)	Percentiles		N	Mean (SE)	Percentiles			
			10	50			90	10	50	90
Age (years)										
12-13	293	89.97 (0.87)	79.11	89.15	101.53	294	87.29 (0.80)	78.25	86.34	96.51
14-15	257	89.90 (1.01)	79.47	89.31	99.52	272	87.06 (0.83)	77.33	85.97	96.15
16-17	268	89.32 (1.05)	79.13	88.58	100.02	300	85.40 (0.61)	76.23	85.20	93.15
18-19	242	90.79 (0.96)	78.70	90.20	101.05	235	85.25 (0.78)	75.61	84.97	93.23
Race/ethnicity and Age (years)										
Non-Hispanic White										
12-13	78	90.24 (1.22)	77.61	89.40	101.55	70	88.23 (1.16)	80.15	86.86	96.43
14-15	55	90.05 (1.36)	79.09	89.10	100.23	82	87.19 (1.06)	77.79	85.88	95.80
16-17	77	89.44 (1.37)	78.46	88.63	100.52	72	85.16 (0.89)	75.79	85.15	92.30
18-19	58	92.20 (1.26)	79.66	90.99	103.31	70	85.55 (1.02)	73.73	85.51	92.86
Non-Hispanic Black										
12-13	90	87.51 (0.92)	78.03	86.33	98.90	101	84.94 (0.69)	75.48	84.37	92.64
14-15	98	89.00 (1.06)	80.74	88.03	99.03	81	85.73 (1.08)	75.44	84.32	95.49
16-17	83	87.88 (1.30)	75.83	86.00	100.28	113	85.06 (1.11)	75.30	84.70	95.11
18-19	80	89.57 (1.09)	79.08	89.33	99.27	85	84.22 (1.17)	75.25	82.13	96.75
Mexican American										
12-13	114	88.90 (1.02)	78.62	87.95	97.58	108	89.01 (1.14)	77.27	87.47	98.47
14-15	93	90.72 (1.99)	80.60	87.97	97.73	93	88.35 (0.88)	77.32	87.73	98.01
16-17	100	90.06 (0.69)	79.48	89.65	98.37	93	85.86 (0.93)	75.11	84.18	94.79
18-19	93	90.23 (1.21)	78.78	89.44	99.49	69	84.36 (0.71)	75.59	84.60	90.71

Table 4.8 Glucose Level Distribution (mg/dL) among US Adolescents (12-19 years old) by Age, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994 (cont'd)

Population	Boys					Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Poverty Income Ratio ^a and Age										
< 1										
12-13	134	88.90 (1.62)	78.63	88.35	99.79	117	87.00 (0.80)	78.31	85.85	94.93
14-15	108	89.02 (1.72)	75.53	88.19	98.49	100	88.76 (1.4)	74.93	88.01	94.65
16-17	112	90.83 (1.27)	79.64	88.93	101.86	122	84.57 (0.82)	76.02	83.76	91.87
18-19	118	91.62 (2.28)	75.67	91.03	106.51	107	85.87 (1.25)	77.25	84.84	96.14
≥ 1 and < 2										
12-13	68	91.07 (3.35)	75.00	89.22	-	79	85.79 (0.96)	76.58	85.35	95.79
14-15	75	90.42 (1.65)	78.35	89.78	99.58	69	86.81 (1.33)	78.39	86.71	92.85
16-17	72	88.52 (1.70)	77.11	86.96	100.09	80	86.71 (1.04)	77.80	86.20	94.84
18-19	60	91.59 (1.81)	82.91	89.16	104.22	57	85.85 (1.15)	77.59	85.78	92.67
≥ 2										
12-13	91	89.96 (1.10)	79.45	89.38	97.97	98	87.99 (1.34)	79.16	86.80	97.24
14-15	74	90.24 (1.39)	81.23	88.40	100.85	103	87.29 (1.1)	77.63	85.76	96.56
16-17	84	88.92 (1.44)	79.58	88.62	99.28	98	85.22 (0.96)	75.83	85.08	92.88
18-19	67	89.70 (1.04)	78.89	90.23	98.51	71	84.48 (1.04)	73.37	84.11	90.96

[†] Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

Table 4.9 Systolic Blood Pressure Percentiles Distribution among US Adolescents (12-19 years old) by Age, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994

Population	Boys				Girls					
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Age (years)										
12-13	301	43.73 (2.57)	7.50	41.21	81.14	301	35.77(2.39)	6.51	32.06	69.95
14-15	263	37.61 (2.31)	7.93	34.41	72.94	284	31.94 (3.04)	4.97	24.88	68.68
16-17	277	33.63 (2.64)	6.21	24.99	75.26	308	30.44 (2.45)	5.49	24.66	64.66
18-19	259	42.78 (2.80)	8.90	40.2	88.50	246	30.56 (1.77)	6.31	27.13	61.81
Race/ethnicity and Age (years)										
Non-Hispanic White										
12-13	76	43.54 (3.77)	5.83	39.32	80.15	74	38.04 (3.56)	7.00	34.56	65.30
14-15	64	38.33 (3.09)	7.94	37.55	73.11	93	30.82 (4.19)	4.08	23.17	65.55
16-17	78	32.43(3.16)	5.31	22.58	75.00	79	28.30 (2.84)	6.01	22.47	58.90
18-19	64	44.98 (4.23)	7.47	44.83	84.90	72	29.49 (2.83)	5.76	24.62	56.94
Non-Hispanic Black										
12-13	102	44.61 (2.91)	12.36	40.75	85.98	103	37.94 (2.75)	3.28	35.14	71.96
14-15	101	42.09 (3.26)	7.71	39.94	73.61	85	35.52 (4.18)	5.91	30.96	74.49
16-17	89	38.11 (3.07)	10.03	31.13	76.82	107	31.61 (3.01)	6.21	27.18	69.59
18-19	87	39.61 (3.22)	8.20	32.20	77.33	91	34.73 (2.22)	5.97	32.11	68.92
Mexican American										
12-13	112	46.84 (2.08)	11.96	44.44	81.46	109	36.86 (3.16)	8.63	30.66	75.82
14-15	91	39.48 (3.02)	7.05	35.91	72.70	92	36.14 (2.81)	5.36	31.57	74.07
16-17	101	37.34 (3.08)	8.72	31.31	73.92	98	33.29 (3.10)	4.41	24.35	70.91
18-19	96	49.79 (2.41)	15.19	48.30	85.45	72	34.52 (2.94)	8.33	25.80	66.27

Table 4.9 Systolic Blood Pressure Percentiles Distribution among US Adolescents (12-19 years old) Age, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994 (cont'd)

Population	Boys					Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Poverty Income Ratio [†] and Age										
<1										
12-13	137	45.21 (3.57)	8.85	46.15	81.21	120	34.69 (3.09)	7.18	29.10	68.20
14-15	109	36.07 (3.54)	8.61	29.45	61.41	102	28.66 (5.33)	5.33	20.30	60.16
16-17	113	30.45 (3.35)	8.09	21.27	63.88	123	30.66 (3.19)	4.66	28.63	63.50
18-19	120	45.76 (3.64)	8.90	45.53	75.84	115	28.85 (2.97)	5.15	22.64	64.43
≥ 1 and < 2										
12-13	69	47.64 (5.99)	6.46	49.27	91.73	80	40.04 (4.19)	3.04	36.68	78.74
14-15	73	31.53 (3.16)	4.97	29.71	62.90	73	35.30 (6.12)	4.91	23.18	89.96
16-17	78	37.81 (4.93)	6.20	27.93	83.40	82	31.74 (6.00)	6.39	22.40	70.82
18-19	65	46.21 (6.21)	5.24	44.68	86.80	58	34.11 (3.25)	12.71	30.93	63.69
≥ 2										
12-13	95	41.20 (3.76)	6.24	36.41	78.70	101	34.56 (3.70)	6.55	31.98	63.66
14-15	81	41.70 (4.08)	8.97	37.98	81.66	109	31.79 (3.90)	4.45	27.10	62.67
16-17	86	33.61 (3.81)	5.35	23.50	74.74	103	29.60 (3.29)	5.59	24.42	61.81
18-19	74	38.77 (3.63)	8.07	32.93	73.04	73	30.41 (2.45)	6.18	29.52	56.05

[†] Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

[§] Age-sex-height specific blood pressure percentiles calculated from nine U.S studies used in the Report of the Second Task Force on Blood Pressure Control in Children (96)

Table 4.10 Diastolic Blood Pressure Percentile^s Distribution among US Adolescents (12-19 years old) by Age, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994.

Population	Boys					Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Age (years)										
12-13	272	34.42 (2.53)	4.41	27.62	69.09	284	32.60 (1.91)	2.12	24.57	57.09
14-15	247	35.54 (2.43)	3.58	36.37	71.82	265	32.91 (2.76)	5.26	27.33	67.68
16-17	272	37.29 (2.52)	6.73	33.21	73.21	301	31.78 (2.10)	4.27	26.98	64.98
18-19	256	45.09 (2.17)	7.79	46.61	75.70	246	36.51 (1.75)	9.69	35.34	66.12
Race/ethnicity and Age (years)										
Non-Hispanic White										
12-13	68	35.86 (3.32)	4.82	27.25	68.22	70	27.48 (2.65)	2.12	21.97	55.13
14-15	62	35.28 (3.09)	3.58	35.85	65.80	87	34.20 (3.41)	5.99	28.23	67.93
16-17	77	36.55 (3.34)	4.73	29.42	70.81	78	32.15 (3.11)	4.21	26.84	65.24
18-19	63	43.20 (3.05)	7.06	43.73	76.02	72	35.01 (2.00)	8.99	33.94	61.57
Non-Hispanic Black										
12-13	92	29.80 (3.19)	1.82	25.37	66.02	95	35.01 (3.75)	1.35	33.15	71.62
14-15	95	39.37 (3.23)	8.10	36.34	82.00	75	29.93 (3.36)	1.83	25.71	65.55
16-17	89	44.30 (3.49)	10.22	42.23	77.35	105	34.50 (3.51)	5.13	33.31	66.31
18-19	87	51.55 (2.50)	14.88	54.77	78.94	91	38.63 (3.45)	9.77	36.60	70.26
Mexican American										
12-13	102	30.17 (3.46)	1.19	24.25	69.23	105	27.41 (1.86)	2.46	18.48	58.92
14-15	84	36.55 (4.81)	3.00	35.60	73.29	89	30.12 (2.88)	1.86	24.84	66.85
16-17	98	35.35 (2.55)	7.93	32.63	65.82	96	30.35 (2.77)	3.47	24.50	65.60
18-19	94	46.14 (2.54)	10.31	46.12	75.94	72	35.49 (2.60)	6.60	34.12	65.69

Table 4.10 Diastolic Blood Pressure Percentile[‡] Distribution among US Adolescents (12-19 years old) by Age, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994 (cont'd)

Population	Boys					Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Poverty Income Ratio [†] and Age										
< 1										
12-13	125	35.50 (4.77)	1.63	27.73	75.44	114	29.50 (2.52)	3.92	26.27	58.24
14-15	101	34.41 (3.43)	6.68	37.91	55.86	96	27.24 (3.30)	4.19	22.67	60.98
16-17	110	36.53 (3.07)	14.08	33.09	67.23	119	29.28 (4.04)	1.51	22.35	64.00
18-19	118	42.98 (5.29)	6.90	43.02	79.91	115	35.80(3.26)	8.81	35.38	66.22
≥ 1 and < 2										
12-13	60	39.61 (6.35)	9.60	25.29	72.20	74	31.76 (4.04)	2.48	25.37	57.66
14-15	68	27.79 (4.54)	4.31	19.71	58.40	68	31.69 (4.10)	5.94	31.70	58.01
16-17	76	35.08 (4.73)	1.98	24.77	76.88	80	29.62 (3.01)	7.29	28.85	51.17
18-19	65	42.56 (3.86)	14.72	41.58	70.85	58	37.47 (2.78)	11.20	30.42	78.30
≥ 2										
12-13	87	31.57 (2.89)	3.64	27.62	63.83	96	27.69 (2.81)	2.05	21.88	55.98
14-15	78	40.09 (4.11)	1.98	40.41	77.69	101	35.77 (3.71)	5.32	28.74	70.29
16-17	86	38.39 (4.34)	5.29	33.97	69.93	102	34.33 (3.58)	4.11	31.54	66.69
18-19	73	48.02 (3.47)	15.54	48.22	74.07	73	36.67 (2.59)	7.31	36.44	58.91

‡ Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

§ Age-sex-height specific blood pressure percentiles calculated from nine U.S studies used in the Report of the Second Task Force on Blood Pressure Control in Children (96)

Table 4.11 Prevalence Estimates of Markers of Metabolic Syndrome for Boys and Girls (12-19 Years old) by Age Group in the Population: NHANES III, 1988-1994

Biomarkers	Boys							
	12-13		14-15		16-17		18-19	
	%	SE	%	SE	%	SE	%	SE
BMI-for-Age Percentiles**								
≥ 85 th - < 95 th	20.43 [#]	3.85	23.04 [†]	4.99	11.72	3.28	6.97 ^{††}	2.03
≥ 95 th	10.38	2.05	8.26	2.05	13.60	3.08	11.30	4.03
Waist Circumference (cm)								
≥ 90 th Percentile	10.77	2.27	10.78	2.27	10.38	2.74	13.58	4.30
Triglycerides (mg/dL)								
≥ 110 mg/dL	23.05	4.30	14.04 ^{††}	3.67	27.35	6.11	33.32 ^{††}	6.06
HDL Cholesterol (mg/dL)								
≤ 40mg/dL	21.55 ^{†††}	4.58	32.69	5.67	35.15 ^{†††}	4.35	37.58	3.67
Serum Glucose (mg/dL)								
≥ 110 mg/dL	4.26	2.76	0.08	0.08	2.82	1.72	2.05	1.62
Total Cholesterol (mg/dL)								
≥ 200 mg/dL	8.17	2.31	3.37 ^{‡‡§§}	1.38	11.16 ^{‡‡}	3.26	14.11 ^{§§}	4.25
LDL-Cholesterol (mg/dL)								
≥ 130 mg/dL	8.50	2.37	4.24 ^{##}	1.71	12.15	3.29	13.23 ^{##}	4.35
Systolic Blood Pressure Percentiles[§]								
≥ 90 th - < 95 th	1.34	0.76	1.10	0.61	1.74	1.42	3.57	1.64
≥ 95 th	5.17	2.68	0.06	0.07	1.07	0.77	2.11	1.59
Diastolic Blood Pressure Percentiles[§]								
≥ 90 th - < 95 th	1.33	0.94	2.03	1.57	0.91	0.92	0.06	0.06
≥ 95 th	0.00	0.00	0.00	0.00	0.19	0.19	0.22	0.13
C-reactive Protein (mg/dL)								
> 0.22 mg/dL	8.01	2.60	9.72	2.96	10.59	3.02	7.95	3.73

- **** BMI-for-Age Percentiles calculated from the CDC growth charts developed by National Center for Health Statistics. If a child is between the 85th and 95th percentile, the child is then classified as at risk for overweight, If the child is above the 95th percentile, the child is classified as overweight
- §** Age-sex-height specific blood pressure percentiles calculated from nine U.S studies used in the Report of the Second Task Force on Blood Pressure Control in Children (96)
- #** p < 0.01 Significant difference between 12-13 year old and 18-19 year old boys ;
- †** p < 0.01 Significant difference between 14-15 year old and 18-19 year old boys ;
- §** p < 0.05 Significant difference between 14-15 year old and 18-19 year old boys;
- ††** p < 0.01 Significant difference between 14 – 15 year old boys and 18-19 year old boys;
- ‡‡** p < 0.05 Significant difference between 14-15 and 16-17 year old boys;
- §§** p < 0.05 Significant difference between 14-15 year old and 18-19 year old boys;
- ##** p < 0.05 Significant difference between 14-15 and 18-19 year old boys;
- †††** p < 0.001 Significant difference between 12-13 and 16-17 year old boys;

Table 4.11 Prevalence Estimates of Markers of Metabolic Syndrome for Boys and Girls (12-19 Years old) by Age Group in the Population: NHANES III, 1988-1994 (cont'd)

Biomarkers	Girls							
	12-13		14-15		16-17		18-19	
	%	SE	%	SE	%	SE	%	SE
BMI-for-Age Percentiles**								
≥ 85 th - < 95 th	13.72	2.21	18.39 [§]	3.22	17.30	2.99	10.04 [§]	2.65
≥ 95 th	13.37	2.62	10.94	3.13	9.87	1.71	9.24	2.69
Waist Circumference (cm)								
≥ 90 th Percentile	10.64	2.23	12.1	3.18	12.36	2.66	10.99	3.23
Triglycerides (mg/dL)								
≥ 110 mg/dL	18.92	4.04	21.08	4.28	20.35	3.78	19.81	3.71
HDL Cholesterol (mg/dL)								
≤ 40mg/dL	12.83	3.47	13.60	2.84	21.43	4.16	12.27	2.75
Serum Glucose (mg/dL)								
≥ 110 mg/dL	0.24	0.15	0.53	0.33	0.33	0.20	0.33	0.19
Total Cholesterol (mg/dL)								
≥ 200 mg/dL	10.80	2.65	8.08	2.22	10.36	2.08	15.86	3.51
LDL-Cholesterol (mg/dL)								
≥ 130 mg/dL	7.77	2.16	10.53	3.17	12.12	2.24	15.24	3.59
Systolic Blood Pressure Percentiles[§]								
≥ 90 th - < 95 th	1.96	0.85	2.34	1.68	0.25	0.16	0.20	0.20
≥ 95 th	1.56	1.39	0.29	1.15	0.15	0.09	0.11	0.11
Diastolic Blood Pressure Percentiles[§]								
≥ 90 th - < 95 th	0.10	0.08	0.21	0.21	0.00	0.00	0.87	0.86
≥ 95 th	0.00	0.00	0.00	0.00	0.25	0.20	0.24	0.17
C-reactive Protein (mg/dL)								
> 0.22 mg/dL	8.72 ^{†††}	2.82	7.40 ^{†††}	2.92	11.35	2.47	20.25 ^{†††}	3.47

** BMI-for-Age Percentiles calculated from the CDC growth charts developed by National Center for Health Statistics. If a child is between the 85th and 95th percentile, the child is then classified as at risk for overweight, If the child is above the 95th percentile, the child is classified as overweight

§ Age-sex-height specific blood pressure percentiles calculated from nine U.S studies used in the Report of the Second Task Force on Blood Pressure Control in Children (96)

††† p < 0.01 Significant difference 12-13 years old, 14-15 years old and 18-19 year old girls

Table 4.12 BMI-for-Age Percentile[†] Distribution among US Adolescents (12-19 years old) by Tanner stage, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994

Population Group	Boys					Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Tanner stage and Gender										
1	76	49.91 (7.00)	2.95	39.25	96.50	7	45.14 (21.17)	-	5.71	-
2	57	62.51 (5.70)	9.85	67.18	96.64	38	58.13 (12.00)	9.14	76.41	91.70
3	107	56.71 (4.45)	12.32	58.42	97.24	93	56.00 (5.20)	25.14	57.33	96.89
4	210	55.33 (3.08)	20.81	52.11	88.70	354	57.38 (2.45)	12.45	60.49	95.89
5	571	56.84 (2.39)	13.92	59.99	96.35	531	62.35 (2.27)	23.53	65.53	94.79
Race/ethnicity and Tanner stage										
Non-Hispanic White										
1	18	52.29 (9.66)	2.65	41.98	93.90	4	41.66 (23.02)	-	-	-
2	9	60.82 (9.20)	6.56	65.15	86.55	8	81.43 (5.22)	-	84.95	90.55
3	25	61.06 (5.46)	14.49	62.17	97.29	22	55.78 (6.99)	16.35	57.36	93.16
4	61	57.21 (4.01)	20.57	54.46	88.93	108	57.08 (3.76)	15.64	58.97	95.40
5	135	57.21 (3.14)	12.07	60.32	96.26	130	58.48 (3.12)	16.84	59.14	92.88
Non-Hispanic Black										
1	17	37.35 (9.88)	0.23	29.38	97.32	1	71.76 (0.00)	-	-	-
2	25	67.23 (6.43)	13.27	81.42	98.38	7	48.97 (14.19)	-	20.87	92.82
3	42	47.59 (5.51)	7.17	38.69	97.14	20	61.38 (12.77)	0.88	36.04	91.58
4	63	58.26 (4.53)	17.33	58.21	96.79	95	65.68 (5.06)	10.32	76.53	98.25
5	215	57.96 (2.15)	13.02	60.28	93.79	227	63.99 (2.27)	17.92	71.62	96.43
Mexican American										
1	38	63.91 (4.38)	7.20	71.84	97.85	2	80.50 (4.06)	-	-	-
2	22	57.93 (8.25)	5.37	63.14	96.23	20	52.96 (6.05)	12.27	50.33	96.35
3	34	57.93 (8.25)	21.49	81.08	98.20	48	74.62 (4.27)	13.10	85.76	97.45
4	79	68.92 (5.09)	16.08	54.44	91.50	126	68.48 (2.59)	27.14	75.78	96.76
5	203	56.29 (2.87)	17.66	70.10	96.64	147	65.45 (2.98)	27.15	69.00	95.83

Table 4.12 BMI-for-Age Percentile Distribution among US Adolescents (12-19 years old) by Tanner stage, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994 (cont'd)

Population Group	Boys					Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Poverty Income Ratio [†] and Tanner stage										
< 1										
1	30	38.70 (6.06)	1.21	35.96	94.62	3	92.20 (5.94)	-	-	-
2	31	73.66 (5.35)	8.86	89.07	98.80	14	61.99 (10.86)	14.53	71.28	87.32
3	50	64.08 (7.27)	17.02	76.32	97.43	36	80.91 (4.20)	47.26	77.35	-
4	83	55.20 (3.81)	27.09	57.00	84.87	140	59.62 (4.05)	12.57	60.86	96.52
5	246	54.78 (4.39)	13.66	53.32	96.60	226	67.75 (2.89)	27.90	72.04	95.42
≥ 1 and < 2										
1	18	57.70 (13.32)	25.43	32.05	96.89	0	-	-	-	-
2	9	72.99 (7.26)	36.55	63.77	-	9	56.58 (6.74)	13.16	49.35	91.71
3	32	49.28 (9.27)	12.94	39.47	91.82	22	49.85 (8.06)	3.26	58.81	72.05
4	53	64.60 (5.16)	3.16	55.58	93.84	103	56.85 (4.80)	9.81	62.22	95.21
5	158	56.25 (3.69)	8.90	56.44	96.80	136	63.12 (4.27)	12.38	65.39	96.45
≥ 2										
1	28	50.37 (9.43)	2.71	53.85	92.66	4	24.70 (18.48)	-	-	-
2	17	50.31 (11.20)	9.55	63.30	86.72	15	57.58 (14.36)	8.99	79.52	89.30
3	25	55.61 (6.49)	5.76	59.06	96.63	35	47.95 (5.51)	17.40	37.21	93.48
4	74	50.54 (4.24)	14.76	44.72	86.61	111	56.73 (3.37)	19.95	57.66	95.45
5	167	58.40 (2.71)	19.53	60.64	93.29	169	58.20 (2.86)	21.86	59.76	91.44

† BMI-for-Age Percentiles calculated from the CDC growth charts developed by National Center for Health Statistics : Between 85th and 95th -- At risk for Overweight; > 95th percentile - Overweight

‡ Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

Table 4.13 Waist Circumference (cm) Distribution among US Adolescents (12-19 years old) by Tanner stage, within Gender, Race/ethnicity and Poverty Income Ratio: NHANES III, 1988-1994

Population Group	Boys					Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Tanner stage and Gender										
1	75	69.84 (1.80)	58.61	66.65	84.59	7	70.20 (9.16)	-	56.12	-
2	57	75.22 (1.98)	59.24	75.65	88.00	37	70.98 (2.73)	57.50	72.18	82.50
3	106	74.85 (1.96)	60.43	70.40	97.56	95	74.95 (3.40)	61.82	67.38	91.58
4	209	74.73 (0.89)	64.77	73.17	85.35	354	74.42 (0.83)	62.09	71.88	89.95
5	563	80.25 (0.80)	69.17	77.23	97.55	525	77.90 (1.08)	66.42	75.23	93.54
Race/ethnicity and Tanner stage										
Non-Hispanic White										
1	17	69.87 (2.45)	55.33	67.32	83.67	4	69.62 (10.12)	-	-	-
2	9	74.87 (3.14)	-	76.10	-	8	76.03 (1.78)	-	75.96	82.16
3	25	76.41 (2.69)	60.46	71.70	99.85	24	74.42 (5.18)	62.07	67.29	91.22
4	61	75.06 (1.06)	65.55	73.63	85.61	108	74.81 (1.32)	63.18	72.00	89.70
5	130	81.10 (1.18)	71.10	77.47	98.69	126	76.88 (1.53)	66.00	73.26	92.56
Non-Hispanic Black										
1	17	67.28 (4.67)	54.98	60.54	95.34	1	78.90 (0.00)	-	-	-
2	25	75.93 (3.06)	57.11	69.62	99.24	6	72.70 (4.40)	-	64.15	82.43
3	42	71.60 (2.82)	58.81	64.70	9.72	20	80.77 (10.48)	58.18	67.52	-
4	63	74.67 (1.80)	64.48	69.73	2.02	95	76.95 (1.99)	62.24	69.63	98.49
5	213	76.71 (0.89)	66.42	73.79	88.9	225	78.52 (1.16)	65.03	75.33	94.37
Mexican American										
1	38	76.20 (2.29)	59.89	72.19	94.55	2	73.12 (0.79)	-	-	-
2	22	74.41 (3.33)	58.02	71.93	93.91	20	69.06 (2.89)	55.07	68.99	85.95
3	34	74.41 (3.33)	63.18	77.98	97.28	48	79.76 (1.64)	64.07	78.49	98.23
4	78	80.25 (3.00)	66.15	72.35	87.80	126	75.68 (1.07)	64.91	73.91	91.00
5	202	75.85 (1.05)	69.58	81.14	98.56	147	78.02 (1.00)	66.09	76.04	92.78

Table 4.13 Waist Circumference (cm) Distribution among US Adolescents (12-19 years old) by Tanner stage, within Gender, Race/ethnicity and Poverty Income Ratio: NHANES III, 1988-1994 (cont'd)

Population Group			Boys			Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Poverty Income Ratio [‡] and Tanner stage										
< 1										
1	30	67.44 (2.32)	56.22	63.44	83.52	3	94.26 (6.09)	-	-	-
2	31	80.92 (2.76)	58.69	78.10	104.70	13	68.73 (2.26)	55.09	72.14	72.79
3	49	81.38 (3.97)	63.09	73.05	107.10	37	91.64 (9.14)	66.78	80.58	132.00
4	82	74.06 (1.50)	64.50	72.89	81.75	140	75.08 (1.54)	61.83	71.62	91.38
5	243	80.56 (1.62)	68.82	76.25	101.24	226	80.57 (1.53)	68.01	77.13	101.62
≥ 1 and < 2										
1	18	72.27 (4.68)	56.36	67.12	84.92	0	-	-	-	-
2	9	75.57 (3.47)	62.10	70.46	86.00	9	69.84 (3.18)	56.41	64.13	80.99
3	32	69.36 (1.75)	63.02	66.63	78.82	22	69.96 (2.06)	59.79	70.25	73.59
4	52	76.49 (1.31)	65.85	75.67	85.32	103	74.90 (1.54)	60.47	73.20	89.75
5	155	80.73 (1.15)	68.03	79.71	96.95	134	79.73 (1.65)	66.33	78.92	92.91
≥ 2										
1	27	69.78 (2.36)	56.86	65.97	83.22	4	59.76 (4.73)	-	-	-
2	17	72.66 (3.72)	56.02	74.65	-	15	71.59 (3.48)	-	71.99	81.75
3	25	73.34 (3.10)	59.59	69.43	92.43	36	69.75 (1.89)	62.00	66.73	83.60
4	75	74.15 (1.14)	64.53	71.39	87.92	111	73.80 (1.01)	63.27	71.38	85.53
5	165	79.85 (0.74)	70.75	77.35	93.43	165	75.13 (1.06)	64.35	72.46	88.05

[‡] Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

Table 4.14 Triglyceride Level (mg/dL) Distribution among US Adolescents (12-19 years old) by Tanner stage, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994

Population Group	Boys					Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Tanner stage and Gender										
1	74	80.09 (6.84)	42.89	68.29	107.78	7	78.47 (9.36)	46.33	61.80	99.87
2	53	96.82 (7.80)	50.67	85.80	135.53	39	96.96 (12.86)	60.28	73.06	166.80
3	102	102.93 (11.76)	49.61	83.77	138.21	89	99.72 (11.53)	50.33	79.20	197.39
4	194	81.94 (4.70)	44.02	71.64	131.33	339	86.15 (4.66)	43.11	72.24	129.82
5	547	94.19 (4.26)	47.59	81.45	156.36	509	87.09 (3.25)	45.57	72.77	150.59
Race/ethnicity and Tanner stage										
Non-Hispanic White										
1	18	80.30 (9.53)	-	65.90	106.53	4	79.14 (10.15)	-	-	-
2	9	101.11 (10.22)	52.65	98.61	131.88	8	123.90 (17.57)	65.76	106.73	170.62
3	23	111.48 (19.34)	52.99	83.58	194.04	23	116.07 (16.19)	60.61	96.90	233.61
4	57	85.6 (6.03)	47.65	79.79	134.99	99	90.11 (6.82)	41.48	72.79	134.00
5	128	96.80 (6.02)	49.23	82.66	162.66	123	89.04 (4.17)	44.64	74.24	151.33
Non-Hispanic Black										
1	17	74.61 (7.04)	46.37	71.06	104.17	1	63.00 (0.00)	-	-	-
2	21	81.71 (11.72)	36.73	72.58	107.43	7	63.39 (6.06)	-	60.04	-
3	40	68.48 (4.51)	36.93	60.62	94.74	18	82.78 (15.87)	40.66	62.83	141.25
4	58	85.64 (12.68)	41.81	68.43	146.31	91	67.93 (3.35)	39.60	66.25	93.72
5	202	74.75 (2.36)	38.69	66.81	115.56	215	71.66 (2.61)	41.60	63.54	99.73
Mexican American										
1	36	83.11 (7.60)	40.21	74.72	125.89	2	78.99 (33.89)	-	-	-
2	22	99.93 (15.37)	51.11	75.30	181.61	21	95.00 (7.85)	47.64	80.38	151.40
3	34	91.63 (10.64)	43.35	77.20	145.59	45	95.00 (7.85)	52.08	78.94	130.35
4	72	79.42 (7.85)	41.44	64.15	124.00	126	90.05 (4.71)	51.43	80.09	129.81
5	199	105.33 (6.57)	47.49	89.07	184.57	144	88.83 (4.50)	47.22	76.21	158.91

Table 4.14 Triglyceride Level (mg/dL) Distribution among US Adolescents (12-19 years old) by Tanner stage, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994 (cont'd)

Population Group		Boys				Girls					
		N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
				10	50	90			10	50	90
Poverty Income Ratio [†] and Tanner stage											
< 1											
1	1	30	71.31 (4.82)	42.71	60.38	112.90	3	96.49 (14.05)	-	-	-
2	2	30	99.09 (13.98)	46.91	76.40	182.98	15	100.22 (8.06)	63.21	96.18	145.94
3	3	47	119.44 (26.49)	48.69	93.16	136.84	33	97.13 (16.67)	49.07	75.64	-
4	4	76	82.57 (8.33)	46.79	71.69	118.10	137	81.58 (4.74)	41.98	73.61	120.14
5	5	237	101.87 (7.86)	47.97	83.11	196.79	217	85.36 (4.80)	47.42	69.55	144.29
≥ 1 and < 2											
1	1	18	89.04 (4.17)	59.18	90.63	99.80	0	-	-	-	-
2	2	9	86.03 (16.61)	42.33	67.92	-	9	79.37 (6.31)	-	73.10	86.00
3	3	31	105.62 (25.95)	48.06	66.38	271.26	21	96.66 (10.92)	45.88	84.24	143.11
4	4	49	97.10 (12.20)	38.48	86.61	151.89	97	88.91 (12.66)	49.10	65.77	129.54
5	5	154	94.94 (5.37)	45.44	86.94	149.61	129	79.29 (4.36)	44.82	68.67	125.51
≥ 2											
1	1	26	79.83 (9.47)	39.20	63.79	107.83	4	70.65 (5.14)	-	-	-
2	2	14	100.85 (8.37)	52.55	100.14	130.56	15	99.00 (16.61)	60.24	66.56	162.28
3	3	24	88.5 (7.29)	53.20	83.17	123.37	35	101.49 (17.28)	50.31	78.69	221.77
4	4	69	73.99 (4.22)	45.40	72.50	107.59	105	86.52 (6.56)	40.56	73.30	136.48
5	5	156	88.79 (5.24)	47.73	73.48	129.46	163	91.59 (5.01)	44.34	78.09	159.10

[†] Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

Table 4.15 Total Cholesterol Level (mg/dL) Distribution among US Adolescents (12-19 years old) by Tanner stage, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994

Population Group	Boys					Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Tanner stage And Gender										
1	74	169.87 (5.55)	133.80	170.94	197.62	7	160.40 (14.94)	-	150.60	-
2	53	176.78 (5.08)	150.50	172.09	207.00	39	169.22 (4.41)	141.04	158.09	191.94
3	102	163.83 (2.37)	140.21	162.19	185.12	89	170.32 (4.29)	140.58	162.44	207.22
4	194	151.98 (2.51)	118.37	148.07	183.15	339	161.99 (1.76)	127.27	160.06	196.45
5	550	159.44 (2.20)	119.58	155.27	200.00	510	165.02 (2.52)	126.19	157.43	211.64
Race/ethnicity and Tanner stage										
Non-Hispanic White										
1	18	168.75 (7.85)	-	171.08	197.23	4	160.62 (15.56)	-	-	-
2	9	178.93 (7.61)	-	171.69	-	8	176.23 (9.70)	-	174.43	191.68
3	23	160.61 (3.30)	137.02	159.11	180.69	23	174.50 (6.41)	142.28	168.82	211.45
4	57	151.47 (3.27)	118.02	146.52	180.57	99	161.61 (2.52)	129.03	157.60	194.43
5	130	157.54 (2.70)	118.04	153.12	199.64	123	161.87 (3.02)	119.27	155.96	197.68
Non-Hispanic Black										
1	17	182.60 (8.45)	136.53	174.65	215.07	1	143.00 (0.00)	-	-	-
2	21	176.60 (4.65)	141.57	177.55	200.88	7	181.82 (10.52)	-	181.71	202.32
3	40	179.30 (6.41)	138.98	176.47	208.29	18	178.23 (10.17)	-	168.35	-
4	58	163.07 (4.68)	126.39	155.97	199.46	91	162.28 (4.92)	113.00	162.54	210.67
5	202	165.21 (2.40)	129.13	159.89	201.51	216	172.68 (2.56)	132.58	164.59	220.71
Mexican American										
1	36	168.62 (4.68)	133.48	165.73	195.90	2	169.32 (0.31)	-	-	-
2	22	163.20 (4.38)	132.77	156.80	199.15	21	166.46 (10.10)	118.02	155.72	212.33
3	34	156.30 (3.83)	128.38	152.14	181.45	45	160.11 (4.27)	123.57	156.37	190.49
4	72	150.86 (2.56)	119.15	146.98	190.70	126	158.66 (2.00)	121.94	150.89	196.81
5	200	164.05 (2.82)	125.32	156.83	204.96	144	164.95 (2.91)	127.27	159.35	200.32

Table 4.15 Total Cholesterol Level (mg/dL) Distribution among US Adolescents (12-19 years old) by Tanner stage, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994 (cont'd)

Population Group	Boys					Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Poverty Income Ratio [†] and Tanner stage										
< 1										
1	30	186.82 (6.78)	151.16	184.68	215.89	3	127.32 (9.58)	-	-	-
2	47	178.15 (3.85)	142.05	167.49	183.99	15	154.25 (10.60)	123.74	139.08	202.84
3	47	170.12 (4.69)	142.05	167.49	183.99	33	177.01 (7.83)	125.31	181.79	209.70
4	76	161.29 (5.50)	130.41	159.03	191.61	137	165.92 (3.47)	121.61	165.56	203.73
5	237	163.78 (4.77)	116.98	163.15	216.20	128	165.18 (4.14)	126.70	155.90	212.82
≥ 1 and < 2										
1	18	177.53 (5.30)	142.96	176.03	191.09	0	-	-	-	-
2	9	163.76 (6.36)	139.14	155.36	177.84	9	178.90 (8.02)	-	167.60	211.83
3	31	162.08 (7.79)	123.86	155.97	-	21	176.52 (6.51)	140.46	157.21	220.76
4	49	147.49 (5.82)	16.53	142.01	192.02	97	156.96 (3.01)	132.04	155.38	183.67
5	154	158.43 (3.20)	123.66	152.62	197.54	129	162.87 (2.55)	127.38	157.60	195.29
≥ 2										
1	26	164.88 (7.45)	-	166.31	189.99	4	174.77 (14.91)	-	-	-
2	14	182.27 (7.62)	166.30	172.92	-	15	170.88 (5.46)	144.54	157.67	191.51
3	24	160.22 (2.32)	142.89	157.86	171.69	35	166.23 (6.27)	141.92	158.55	198.73
4	69	149.46 (3.55)	116.92	144.98	178.28	105	163.35 (3.08)	126.37	158.09	197.89
5	159	157.04 (2.51)	119.32	154.00	198.85	163	165.82 (4.17)	117.82	158.11	216.62

[†] Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

Table 4.16 HDL-Cholesterol Level (mg/dL) Distribution among US Adolescents (12-19 years old) by Tanner stage, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994

Population Group	Boys				Girls					
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Tanner stage and Gender										
1	74	52.74 (1.46)	37.58	51.69	62.85	7	54.42 (5.55)	-	55.80	62.61
2	53	49.88 (2.05)	35.76	50.00	61.34	39	50.24 (4.50)	31.32	46.74	64.76
3	102	50.25 (1.85)	34.48	47.49	67.13	90	51.39 (1.71)	37.52	51.40	61.93
4	194	46.95 (1.33)	33.21	45.13	62.37	337	51.64 (0.80)	38.28	50.68	63.89
5	543	46.38 (0.73)	35.06	44.47	61.38	506	52.11 (0.79)	35.28	51.46	67.31
Race/ethnicity and Tanner stage										
Non-Hispanic White										
1	18	52.95 (2.10)	36.46	51.99	62.54	4	53.80 (6.11)	-	-	-
2	9	48.39 (2.75)	-	46.88	-	8	42.05 (2.32)	30.45	42.49	46.86
3	23	48.49 (2.89)	33.08	45.50	61.17	23	49.43 (2.31)	37.48	49.32	59.45
4	57	44.83 (1.35)	31.96	43.52	56.56	98	50.58 (1.12)	38.05	48.96	62.41
5	128	44.80 (0.95)	34.73	42.61	57.77	123	51.33 (1.03)	34.25	51.51	66.68
Non-Hispanic Black										
1	17	56.44 (3.34)	38.95	53.69	68.94	1	50.00 (0.00)	-	-	-
2	21	56.58 (2.86)	43.65	51.75	73.32	7	64.12(5.99)	34.60	69.29	-
3	40	56.99 (2.11)	40.00	56.86	71.74	19	54.03 (4.19)	-	51.96	-
4	58	54.32 (1.85)	37.35	52.54	69.93	91	53.86 (1.84)	38.42	52.02	70.08
5	199	51.57 (0.97)	37.33	49.89	65.61	212	55.50 (1.10)	41.44	52.93	70.57
Mexican American										
1	36	52.22 (3.15)	32.11	52.08	66.65	2	67.17 (8.55)	-	-	-
2	22	46.84 (2.82)	24.58	43.22	61.04	21	51.27 (1.72)	33.08	52.17	62.46
3	34	49.26 (2.43)	32.16	46.93	64.81	45	47.94 (1.58)	34.93	46.82	59.15
4	72	49.84 (1.97)	37.76	47.69	65.32	125	51.51 (0.58)	41.01	51.47	60.81
5	198	47.30 (0.79)	33.91	45.70	60.85	144	52.86 (1.06)	37.87	50.49	69.36

Table 4.16 HDL-Cholesterol Level (mg/dL) Distribution among US Adolescents (12-19 years old) by Tanner stage, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994 (cont'd)

Population Group	Boys					Girls				
	N	Mean(SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Poverty Income Ratio [†] and Tanner stage										
< 1										
1	30	61.64 (3.78)	44.23	57.77	-	3	41.66 (7.29)	-	-	-
2	30	50.45 (2.42)	34.60	49.63	72.06	15	46.13 (2.61)	33.42	41.69	57.66
3	47	52.14 (2.42)	30.94	47.17	59.51	34	47.72 (2.54)	34.76	45.00	61.72
4	76	44.85 (2.06)	33.18	45.93	63.91	136	52.49 (1.45)	38.79	52.24	64.69
5	235	47.91 (1.58)	35.09	43.46	61.37	216	51.90 (1.94)	33.68	51.07	67.13
≥ 1 and < 2										
1	18	51.03 (1.93)	33.96	51.02	55.42	0	-	-	-	-
2	9	57.42 (2.88)	49.22	52.96	61.61	9	48.68 (9.19)	-	35.65	-
3	31	52.14 (2.42)	37.52	55.09	68.16	21	51.47 (0.69)	39.68	50.34	59.44
4	49	44.85 (2.06)	31.76	43.43	58.22	96	52.16 (1.13)	40.37	52.17	63.31
5	153	47.91 (1.58)	35.18	46.65	62.66	128	52.74 (1.34)	39.09	50.87	64.81
≥ 2										
1	26	51.37 (1.83)	35.29	50.81	62.26	4	59.96 (1.99)	-	-	-
2	14	46.10 (2.15)	29.32	43.58	54.21	15	51.36 (5.24)	31.31	46.82	64.49
3	24	50.69 (3.69)	33.07	45.38	71.24	35	52.61 (2.56)	37.23	52.31	62.48
4	69	47.02 (2.09)	32.30	43.74	60.72	105	50.93 (1.38)	34.65	48.76	66.93
5	155	45.69 (1.19)	34.99	44.14	59.11	162	51.98 (0.88)	34.74	51.61	68.40

[†] Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

Table 4.17 LDL-Cholesterol Level (mg/dL) Distribution among US Adolescents (12-19 years old) by Tanner stage, within Gender, Race/Ethnicity and Poverty Income Ratio : NHANES III, 1988-1994

Population Group	Boys					Girls			
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles	
			10	50	90			10	50
Tanner stage and Gender									
1	74	101.11 (5.13)	62.85	105.27	130.10	7	90.28 (12.42)	-	-
2	53	107.53 (5.24)	77.67	103.45	135.56	39	99.58 (4.65)	76.30	121.04
3	100	93.95 (2.94)	67.66	94.69	118.25	89	99.02 (4.05)	68.87	130.29
4	193	88.53 (2.52)	56.80	83.20	116.57	337	93.69 (1.62)	63.62	128.00
5	542	93.87 (2.04)	61.00	90.07	137.12	506	95.38 (2.39)	60.06	132.52
Race/ethnicity and Tanner stage									
Non-Hispanic White									
1	18	99.73 (7.17)	-	105.20	125.75	4	90.98 (13.80)	-	-
2	9	110.31 (7.99)	-	103.48	-	8	109.40 (7.76)	-	122.36
3	22	91.19 (4.50)	64.96	93.67	113.82	23	101.84 (6.25)	63.59	134.29
4	57	85.52 (3.19)	57.41	82.81	116.65	98	93.84 (2.26)	64.43	125.47
5	128	93.01 (2.47)	59.73	88.14	139.14	123	92.73 (3.21)	54.31	131.20
Non-Hispanic Black									
1	17	111.23 (6.56)	77.33	105.29	131.50	1	80.39 (0.00)	-	-
2	21	103.67 (3.75)	74.55	101.44	130.13	7	105.01 (10.16)	-	120.35
3	40	108.61 (5.17)	74.37	104.33	134.67	18	107.94 (7.27)	59.45	143.26
4	57	90.73 (4.79)	51.77	82.63	129.86	91	94.83 (3.34)	61.49	132.37
5	199	97.98 (1.95)	66.89	96.39	128.89	212	102.49 (2.59)	72.22	148.04
Mexican American									
1	36	99.78 (3.60)	32.11	52.08	66.65	2	86.34 (2.08)	-	-
2	22	96.37 (3.54)	24.58	43.22	61.04	21	96.19 (9.45)	53.32	132.91
3	33	89.15 (3.98)	66.04	86.65	118.49	45	94.15 (4.04)	60.32	122.49
4	72	85.13 (2.54)	59.08	82.78	115.31	125	89.32 (2.03)	57.46	125.78
5	197	95.97 (2.27)	63.67	91.96	131.72	144	93.77 (2.71)	61.22	120.51

Table 4.17 LDL-Cholesterol Level (mg/dL) Distribution among US Adolescents (12-19 years old) by Tanner stage, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994 (cont'd)

Population Group		Boys				Girls					
		N	Mean (SE)	Percentiles		N	Mean (SE)	Percentiles			
				10	50	90			10	50	90
Poverty Income Ratio [‡] and Tanner stage											
< 1											
1	30	110.92 (4.54)	80.45	109.01	132.69	3	66.35 (5.19)	-	-	-	-
2	30	107.88 (3.78)	82.80	102.93	136.82	15	88.07 (9.53)	54.36	76.72	125.36	
3	45	102.07 (4.36)	78.92	96.75	119.14	33	110.08 (5.13)	78.51	114.68	133.01	
4	76	95.90 (5.47)	70.01	86.43	117.07	136	97.13 (2.59)	67.71	96.16	128.79	
5	234	96.64 (4.29)	57.85	91.08	140.12	216	96.00 (3.33)	65.11	88.28	133.46	
≥ 1 and < 2											
1	18	108.68 (3.69)	81.75	107.53	119.71	0	-	-	-	-	-
2	9	89.13 (5.11)	75.34	79.84	100.47	9	114.34 (6.67)	-	111.06	127.98	
3	31	88.81 (7.85)	61.34	75.87	-	21	105.71 (5.83)	72.67	93.74	140.57	
4	48	82.76 (5.21)	54.18	80.95	110.67	96	88.84 (3.28)	61.25	85.43	110.05	
5	153	91.35 (2.92)	61.08	86.33	124.53	128	94.14 (2.56)	59.72	94.51	121.95	
≥ 2											
1	26	97.53 (7.03)	-	103.58	128.13	4	100.67 (14.67)	-	-	-	-
2	14	116.00 (6.91)	94.33	106.08	-	15	99.72 (6.83)	76.35	88.35	119.66	
3	24	91.82 (3.41)	66.22	96.20	103.74	35	93.32 (5.95)	67.11	87.66	128.06	
4	69	87.63 (3.71)	53.34	83.37	116.00	105	95.11 (2.62)	63.30	94.23	130.13	
5	155	93.09 (2.34)	61.19	88.81	135.50	162	95.48 (4.11)	49.34	87.96	142.38	

[†] Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

Table 4.18 Glucose Level (mg/dL) Distribution among US Adolescents (12-19 years old) by Tanner stage, within Gender, Race/Ethnicity and Poverty Income Ratio : NHANES III, 1988-1994

Population Group	Boys					Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Tanner stage and Gender										
1	72	88.27 (1.11)	79.49	88.50	95.56	7	79.94 (3.99)	-	79.19	-
2	53	92.85 (2.45)	80.78	89.99	103.59	38	85.30 (2.52)	-	86.31	93.28
3	98	89.10 (1.05)	77.50	89.09	97.79	88	90.71 (0.88)	82.01	91.05	99.05
4	192	90.91 (1.48)	79.43	88.88	102.34	332	86.44 (0.65)	78.15	85.65	94.08
5	541	90.00 (0.77)	79.11	89.54	99.36	501	85.87 (0.70)	76.20	85.41	94.76
Race/ethnicity and Tanner stage										
Non-Hispanic White										
1	17	87.83 (1.63)	78.06	87.28	95.02	4	80.12 (4.40)	-	-	-
2	9	94.25 (3.68)	78.37	90.45	-	8	88.03 (1.07)	-	86.48	-
3	22	87.94 (1.48)	77.08	88.64	97.28	23	90.26 (1.28)	81.76	90.33	97.62
4	56	92.15 (1.81)	80.04	90.59	103.26	96	86.29 (0.92)	78.35	85.70	93.37
5	128	90.27 (1.08)	79.39	89.70	99.97	121	86.39 (1.04)	75.24	85.83	95.84
Non-Hispanic Black										
1	17	87.67 (2.23)	73.05	89.28	95.63	1	75.00 (0.00)	-	-	-
2	21	90.00 (2.02)	80.58	86.85	102.50	7	84.26 (2.89)	76.68	80.93	90.75
3	38	87.51 (1.49)	76.14	86.42	96.26	19	88.85 (1.41)	83.38	87.61	96.65
4	57	88.14 (1.06)	80.43	86.48	99.71	91	85.58 (1.16)	75.17	84.61	95.20
5	198	88.51 (0.87)	77.00	87.23	98.75	213	84.42 (0.71)	75.37	83.20	95.18
Mexican American										
1	35	89.01 (1.25)	81.40	88.22	95.62	2	80.52 (2.44)	-	-	-
2	22	90.67 (2.43)	79.30	89.55	100.73	20	90.96 (2.79)	-	90.57	98.83
3	33	88.30 (1.68)	75.18	87.09	98.34	43	90.36 (1.62)	77.56	90.07	98.97
4	72	87.88 (1.07)	79.09	87.34	96.72	122	88.18 (0.87)	77.46	87.76	97.25
5	199	91.42 (1.25)	80.97	90.40	98.96	140	85.81 (0.75)	75.88	86.08	93.81

Table 4.18 Glucose Level (mg/dL) Distribution among US Adolescents (12-19 years old) by Tanner stage, within Gender, Race/Ethnicity and Poverty Income Ratio : NHANES III, 1988-1994 (cont'd)

Population Group	Boys					Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Poverty Income Ratio [‡] and Tanner stage										
< 1										
1	30	85.59 (1.57)	70.53	85.62	95.56	3	78.33 (0.67)	-	-	-
2	30	89.21 (1.85)	79.93	86.97	101.28	14	89.62 (2.07)	80.79	87.53	98.77
3	44	89.47 (1.33)	78.53	89.46	94.88	33	89.18 (1.41)	81.50	88.73	96.96
4	76	89.26 (1.57)	80.13	87.28	99.40	133	85.72 (1.02)	74.85	85.27	94.37
5	234	91.58 (1.59)	75.60	91.09	106.31	212	85.77 (0.77)	76.56	85.30	96.37
≥ 1 and < 2										
1	16	85.89 (2.35)	79.20	83.66	92.57	0	-	-	-	-
2	9	87.68 (2.67)	-	89.51	91.59	9	81.89 (3.17)	-	77.21	92.85
3	31	89.38 (2.79)	75.99	89.01	-	20	92.09 (1.96)	84.15	91.13	101.77
4	48	92.72 (3.95)	71.95	88.4	-	96	86.17 (0.74)	79.10	85.72	92.40
5	150	89.84 (1.07)	79.17	89.20	99.66	129	86.88 (1.05)	77.84	86.38	96.51
≥ 2										
1	26	89.18 (1.43)	80.09	89.25	95.40	4	80.63 (5.64)	-	-	-
2	14	96.60 (4.37)	83.36	91.31	-	15	84.94 (3.03)	-	86.23	92.72
3	23	88.60 (2.05)	74.37	88.49	97.43	35	90.83 (1.44)	81.91	91.43	98.52
4	68	90.85 (1.65)	78.99	91.09	10.27	103	86.93 (0.99)	78.65	85.72	96.65
5	157	89.06 (0.94)	79.75	89.21	97.52	160	85.50 (1.07)	74.31	85.25	95.07

[‡] Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

Table 4.19 Systolic Blood Pressure Percentile^a Distribution among US Adolescents (12-19 years old) by Tanner stage, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994

Population Group		Boys				Girls					
		N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
				10	50	90			10	50	90
Tanner stage and Gender											
1	76	39.56 (4.62)	3.42	30.15	78.39	7	37.06 (9.42)	-	31.70	-	-
2	57	33.06 (5.14)	1.51	25.10	69.90	39	34.74 (4.83)	11.68	29.58	61.71	
3	109	43.08 (2.78)	5.97	43.88	73.76	95	30.89 (4.58)	5.92	21.47	69.66	
4	208	40.88 (3.72)	6.78	36.04	81.35	356	34.99 (2.74)	6.51	30.44	73.22	
5	572	39.76 (1.91)	9.24	37.14	75.96	536	31.20 (1.66)	5.98	27.05	62.93	
Race/ethnicity and Tanner stage											
Non-Hispanic White											
1	18	39.73 (6.34)	2.81	25.14	78.43	4	36.05(10.36)	-	-	-	-
2	9	24.89 (7.60)	-	13.46	-	8	40.30 (9.74)	-	39.38	-	-
3	25	40.05 (4.86)	5.36	33.72	70.98	24	32.26 (6.66)	1.38	22.07	64.59	
4	61	43.05 (4.75)	6.55	38.42	81.57	108	34.68 (3.33)	6.41	30.20	68.71	
5	135	40.20 (2.54)	9.03	37.81	79.24	129	29.77 (2.56)	5.66	24.79	61.95	
Non-Hispanic Black											
1	17	40.31 (7.26)	6.68	40.91	67.18	1	53.02 (0.00)	-	-	-	-
2	25	47.42 (4.44)	22.94	41.17	87.24	7	47.23(13.25)	-	43.68	75.30	
3	42	47.13 (4.70)	6.44	44.44	85.93	20	61.64 (5.91)	0.36	25.78	67.16	
4	63	43.77 (4.22)	12.28	40.97	74.57	96	34.31 (2.88)	7.10	32.78	70.58	
5	213	38.24 (1.94)	8.56	31.58	75.93	228	35.11 (1.65)	6.00	31.54	71.26	
Mexican American											
1	38	47.00 (3.50)	6.43	46.64	78.96	2	41.65 (5.35)	-	-	-	-
2	22	42.96 (4.89)	9.61	39.94	78.99	21	33.56 (6.29)	7.87	25.50	65.44	
3	36	50.48 (4.55)	19.62	51.49	77.79	48	42.55 (3.60)	11.42	44.61	76.97	
4	78	39.68 (3.97)	7.02	35.86	81.24	127	37.31 (3.30)	6.66	31.17	74.12	
5	206	42.72 (2.32)	11.15	42.24	80.13	152	32.40 (2.46)	5.07	26.08	68.44	

Table 4.19 Systolic Blood Pressure Percentile[§] Distribution among US Adolescents (12-19 years old) by Tanner stage, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994 (cont'd)

Population Group	Boys					Girls				
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Poverty Income Ratio [†] and Tanner stage										
< 1										
1	30	47.96 (6.75)	12.53	46.59	72.06	3	49.03 (2.12)	-	-	-
2	31	47.34 (5.40)	18.53	37.56	90.74	15	30.62 (7.67)	13.15	17.14	70.78
3	51	43.53 (6.25)	10.10	37.73	85.17	37	35.81 (7.59)	6.13	24.80	72.44
4	82	41.16 (5.55)	8.33	35.10	78.65	141	33.55 (3.37)	8.66	29.45	62.35
5	247	39.28 (2.42)	8.36	43.27	72.31	231	30.01 (2.43)	4.65	24.61	63.29
≥ 1 and < 2										
1	18	50.98 (9.62)	6.08	50.05	78.36	0	-	-	-	-
2	9	12.67 (5.71)	-	1.80	40.38	9	26.73 (9.28)	-	14.08	53.02
3	33	42.77 (6.50)	4.97	43.70	70.37	22	27.93 (6.45)	-	16.40	65.98
4	53	44.24 (7.63)	8.47	38.27	91.83	103	42.12 (5.56)	6.93	38.16	83.69
5	158	42.09 (3.80)	5.80	39.02	84.73	135	32.00 (2.86)	6.30	23.58	65.93
≥ 2										
1	28	35.45 (6.00)	2.86	20.73	78.16	4	31.87(12.03)	-	-	-
2	17	35.69 (7.72)	-	27.17	68.64	15	36.86 (5.29)	8.92	31.10	60.30
3	25	42.91 (5.69)	2.74	43.90	68.52	36	29.80 (6.08)	0.69	23.29	61.87
4	73	38.92 (5.25)	5.61	33.25	77.90	112	30.87 (2.97)	6.11	25.80	60.27
5	167	39.10 (3.09)	10.56	33.01	75.04	170	31.71 (2.49)	6.10	29.13	61.96

[†] Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

[§] Age-sex-height specific blood pressure percentiles calculated from nine U.S studies used in the Report of the Second Task Force on Blood Pressure Control in Children (96)

Table 4.20 Diastolic Blood Pressure Percentile⁴ Distribution among US Adolescents (12-19 years old) by Tanner stage, within Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994

Population Group	Boys				Girls					
	N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
			10	50	90			10	50	90
Tanner stage and Gender										
1	67	37.36 (3.41)	13.94	32.47	80.59	7	21.96 (6.73)	-	21.37	35.32
2	49	27.43 (6.41)	4.53	17.88	67.80	38	24.53 (4.88)	5.40	18.22	-
3	101	25.2 (3.58)	3.94	19.62	64.33	91	26.67 (3.11)	2.49	22.35	50.56
4	206	35.74 (2.76)	3.25	31.75	67.49	345	31.14 (1.94)	3.26	27.36	65.44
5	562	41.02 (1.69)	6.77	40.68	75.46	526	33.32 (1.80)	4.52	31.60	62.25
Race/ethnicity and Tanner stage										
Non-Hispanic White										
1	16	39.06 (5.15)	15.91	30.99	77.13	4	21.76 (7.43)	-	-	-
2	8	26.18 (9.59)	-	13.28	-	8	29.04 (8.05)	-	20.80	-
3	24	23.87 (3.15)	4.18	20.01	39.11	23	24.76 (4.65)	1.55	16.02	46.66
4	61	36.36 (3.66)	1.92	27.17	67.49	104	30.22 (2.40)	2.63	24.57	65.44
5	135	39.21 (2.17)	6.26	38.24	75.11	129	33.48 (2.30)	5.31	31.53	61.73
Non-Hispanic Black										
1	16	33.40 (5.79)	9.01	31.47	59.10	1	20.66 (0.00)	-	-	-
2	21	26.15 (3.62)	4.20	17.69	46.10	7	20.22 (6.03)	-	14.18	-
3	39	27.71 (4.36)	1.35	16.95	62.48	18	26.33 (7.15)	1.78	21.97	-
4	62	37.18 (3.49)	6.04	32.17	73.23	91	35.04 (2.92)	3.29	31.12	72.97
5	209	46.82 (1.95)	11.22	47.74	78.96	219	34.44 (2.54)	3.45	34.12	66.70
Mexican American										
1	33	32.42 (5.16)	0.86	30.05	71.05	2	26.08(11.37)	-	-	-
2	19	36.71 (5.44)	8.91	34.50	51.36	21	19.82 (3.58)	-	13.21	40.84
3	32	21.75 (5.39)	0.97	10.97	57.38	47	28.11 (3.64)	1.79	19.23	60.70
4	77	36.17 (2.56)	8.03	30.07	66.69	125	31.62 (2.69)	3.10	26.30	69.14
5	200	40.28 (1.65)	6.84	42.33	72.80	151	31.67 (2.05)	4.82	26.92	63.26

Table 4.20 Diastolic Blood Pressure Percentile[§] Distribution among US Adolescents (12-19 years old) by Tanner stage, Gender, Race/Ethnicity and Poverty Income Ratio: NHANES III, 1988-1994 (cont'd)

Population Group		Boys				Girls					
		N	Mean (SE)	Percentiles			N	Mean (SE)	Percentiles		
				10	50	90			10	50	90
Poverty Income Ratio and Tanner stage											
< 1											
1		26	47.27 (8.57)	12.18	34.99	-	3	36.33 (6.14)	-	-	-
2		27	26.87 (3.77)	7.32	15.52	50.76	15	24.67 (4.81)	-	25.66	35.33
3		48	25.31 (2.84)	1.43	26.65	48.53	37	22.85 (4.57)	2.67	19.93	41.18
4		82	38.44 (5.05)	5.20	35.99	67.49	137	31.19 (3.01)	5.80	27.72	67.04
5		241	40.38 (3.01)	6.93	40.58	75.61	227	29.68 (2.72)	3.29	22.66	66.14
≥ 1 and < 2											
1		16	41.26 (14.63)	2.24	17.81	80.38	0	-	-	-	-
2		8	17.46 (4.00)	-	9.63	26.31	9	24.66 (4.31)	9.09	18.79	-
3		29	30.82 (9.11)	4.36	13.87	71.47	18	23.47 (4.45)	6.62	13.49	40.25
4		53	34.78 (5.76)	4.46	24.00	62.63	98	31.93 (3.08)	3.76	31.49	56.68
5		154	38.84 (2.88)	5.67	38.26	75.49	133	31.75 (2.40)	6.76	30.53	59.39
≥ 2											
1		25	34.73 (3.29)	17.47	28.58	55.15	4	15.72 (5.72)	-	-	-
2		14	32.58 (11.39)	-	22.39	-	14	24.46 (7.58)	4.73	9.41	-
3		24	21.93 (4.23)	2.54	19.66	53.63	36	29.98 (4.43)	1.95	28.24	51.03
4		71	34.83 (3.54)	0.40	31.34	68.47	110	30.61 (2.58)	2.12	22.97	67.82
5		167	42.32 (3.00)	5.46	40.84	74.14	166	36.57 (2.49)	4.54	34.94	65.45

† Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

§ Age-sex-height specific blood pressure percentiles calculated from nine U.S studies used in the Report of the Second Task Force on Blood Pressure Control in Children (96)

Table 4.21 Prevalence Estimates of Markers of Metabolic Syndrome for Boys (12-19 Years old) by Sexual Maturation Stage (Assessed by Pubic Hair Assessment) in the Population: NHANES III, 1988-1994

Biomarkers	Tanner stage 1		Tanner stage 2		Tanner stage 3		Tanner stage 4		Tanner stage 5	
	%	SE	%	SE	%	SE	%	SE	%	SE
BMI-for-Age Percentiles**										
≥ 85 th - < 95 th	18.49	8.01	17.41	7.85	14.54	5.87	15.36	4.64	15.03	2.42
≥ 95 th	11.77	5.02	14.49	5.42	15.44	4.72	6.26	2.21	11.58	2.38
Waist Circumference (cm)										
≥ 90 th Percentile	7.99	3.82	18.40	8.19	17.86	5.17	5.67	2.23	11.94	2.50
Triglycerides (mg/dL)										
≥ 110 mg/dL	9.36 ^{***}	4.33	28.16	9.87	25.55	5.70	16.47	5.10	26.10 ^{***}	3.95
HDL Cholesterol (mg/dL)										
≤ 40mg/dL	12.16 ^{####†††}	5.51	14.52	8.15	22.67	7.10	31.65 ^{###}	5.71	36.55 ^{††††}	2.66
Serum Glucose (mg/dL)										
≥ 110 mg/dL	0.00	0.00	9.38	8.10	0.00	0.00	4.22	3.21	1.87	1.47
Total Cholesterol (mg/dL)										
≥ 200 mg/dL	8.74	4.39	13.04	5.74	6.22	3.30	5.13 ^{***}	2.00	12.67 ^{***}	2.91
LDL-Cholesterol (mg/dL)										
≥ 130 mg/dL	12.09	6.77	11.09	5.65	6.71	3.32	5.76 ^{\$\$\$}	2.16	13.03 ^{\$\$\$}	2.94
Systolic Blood Pressure Percentiles[§]										
≥ 90 th - < 95 th	0.27 [#]	0.28	0.61	0.63	3.08	2.14	0.47 ^{††}	0.28	2.50 ^{†††}	0.69
≥ 95 th	0.00	0.00	1.88	1.42	0.79	0.58	4.86	3.16	1.79	0.88
Diastolic Blood Pressure Percentiles[§]										
≥ 90 th - < 95 th	5.91	4.06	0.00	0.00	0.00	0.00	1.52	1.47	0.71	0.51
≥ 95 th	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.63
C-reactive Protein (mg/dL)										
> 0.22 mg/dL	3.70	1.52	6.25	2.83	11.78	4.47	9.80	3.68	10.34	2.27

**	BMI-for-Age Percentiles calculated from the CDC growth charts developed by National Center for Health Statistics. If a child is between the 85 th and 95 th percentile, the child is then classified as at risk for overweight, If the child is above the 95 th percentile, the child is classified as overweight
§	Age-sex-height specific blood pressure percentiles calculated from nine U.S studies used in the Report of the Second Task Force on Blood Pressure Control in Children (96)
#	p < 0.01 Significant difference between boys in tanner 1 and boys in Tanner stage 5 ;
††	p < 0.01 Significant difference between boys in Tanner stage 4 and Tanner stage 5;
†††	p < 0.01 Significant in boys between Tanner stage 1 and Tanner stage 5;
***	p < 0.01 Significant difference in boys between Tanner stage 4 and 5;
§§§	p < 0.01 Significant difference in boys between Tanner stage 4 and Tanner stage 5;
###	p < 0.05 Significant difference in boys between Tanner stage 1 and 4;
††††	p < 0.01 Significant difference in boys between Tanner stage 1 and Tanner stage 5

Table 4.22 Prevalence Estimates of Markers of Metabolic Syndrome for Girls (12-19 Years old) by Sexual Maturation Stage (Assessed by Pubic Hair Assessment) in the Population: NHANES III, 1988-1994

Biomarkers	Tanner stage 2		Tanner stage 3		Tanner stage 4		Tanner stage 5	
	%	SE	%	SE	%	SE	%	SE
BMI-for-Age Percentiles**								
≥ 85 th - < 95 th	29.45	13.45	10.25	3.43	12.08 ^{##}	2.34	17.91 ^{†††}	2.48
≥ 95 th	6.14	2.97	13.35	5.80	11.56	2.95	8.66	1.65
Waist Circumference (cm)								
≥ 90 th Percentile	9.93	4.29	17.75	6.13	8.62	1.94	12.17	2.67
Triglycerides (mg/dL)								
≥ 110 mg/dL	29.12	11.96	27.91	8.91	17.92	2.80	20.83	2.92
HDL Cholesterol (mg/dL)								
≤ 40mg/dL	20.19	8.96	18.79	6.38	13.38	2.59	16.39	2.67
Serum Glucose (mg/dL)								
≥ 110 mg/dL	0.73	0.74	0.89	0.58	0.46	0.29	0.27	0.13
Total Cholesterol (mg/dL)								
≥ 200 mg/dL	9.75	4.19	19.21	7.27	8.10	1.55	13.04	1.88
LDL-Cholesterol (mg/dL)								
≥ 130 mg/dL	6.57	3.65	11.56	5.03	9.06	2.01	12.62	1.89
Systolic Blood Pressure Percentiles[§]								
≥ 90 th - < 95 th	0.71	0.64	0.00	0.00	2.89	1.57	0.58	0.34
≥ 95 th	0.45	0.43	0.00 ^{§§}	0.00	1.01	0.99	0.34 ^{††§§}	0.13
Diastolic Blood Pressure Percentiles[§]								
≥ 90 th - < 95 th	0.00	0.00	0.23	0.24	0.00	0.00	0.55	0.45
≥ 95 th	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.09
C-reactive Protein (mg/dL)								
> 0.22 mg/dL	16.98	11.93	8.93	3.82	10.68	2.09	11.89	2.41

- Among girls there were to few people in Tanner stage 1, therefore Tanner stage one data is not represented in this table.
- ** BMI-for-Age Percentiles calculated from the CDC growth charts developed by National Center for Health Statistics.
If a child is between the 85th and 95th percentile, the child is then classified as at risk for overweight, If the child is above the 95th percentile, the child is classified as overweight;
- § Age-sex-height specific blood pressure percentiles calculated from nine U.S studies used in the Report of the Second Task Force on Blood Pressure Control in Children(96);
- †† $p < 0.05$ Significant difference girls in Tanner stage 1 and Tanner stage 5;
- §§ $p < 0.05$ Significant difference between girls in Tanner stage 3 and Tanner stage 5;
- ## $p < 0.01$ Significant difference in girls between Tanner stage 1 and Tanner stage 4;
- ††† $p < 0.001$ Significant difference in girls between Tanner stage 1 and Tanner stage 5 ;

Table 4.23 Correlation between biomarkers related to MS in Adolescent Boys and Girls (12-19 years old): NHANES III, 1988-1994

	BMI	WC	TC	LDL-C	HDL-C	TG	Glucose	SBP	DBP
Boys (n=938)									
BMI									
WC	0.72								
TC	0.07	0.10							
LDL-C	0.10	0.13	0.91						
HDL-C	-0.23	-0.33	0.23	-0.05					
TG	0.23	0.32	0.31	0.12	-0.34				
Glucose	0.16	0.19	0.06	0.07	-0.08	0.09			
SBP	0.29	0.23	0.16	0.14	-0.12	0.26	0.09		
DBP	-0.01	0.07	-0.06	-0.06	0.00	-0.03	0.03	0.20	
Girls (n=993)									
BMI									
WC	0.74								
TC	0.02	0.02							
LDL-C	0.08	0.07	0.92						
HDL-C	-0.31	-0.33	0.20	-0.08					
TG	0.21	0.26	0.26	0.10	-0.34				
Glucose	0.03	0.25	0.01	0.02	-0.05	0.03			
SBP	0.29	0.01	0.02	0.04	-0.08	0.05	0.11		
DBP	0.05	0.11	0.06	0.06	-0.06	0.09	0.06	0.29	

BMI: BMI-for-age percentiles; WC: Waist Circumference (cm); TC: Total cholesterol (mg/dL); LDL-C: LDL-cholesterol; HDL-C: HDL-cholesterol; TG: Triglycerides; SBP: Systolic blood pressure percentiles; DBP: Diastolic Blood Pressure Percentiles.

Table 4.24 Correlation between biomarkers related to MS in Adolescent Boys (12-19 years old) stratified by Age: NHANES III, 1988-1994

	BMI	WC	TC	LDL-C	HDL-C	TG	Glucose	SBP	DBP
12-13 (n=242)									
BMI									
WC	0.80								
TC	-0.13	-0.16							
LDL-C	-0.10	-0.08	0.91						
HDL-C	-0.32	-0.42	0.27	0.00					
TG	0.24	0.24	0.12	-0.08	-0.36				
Glucose	0.12	0.15	0.10	0.06	-0.05	0.18			
SBP	0.19	0.17	0.05	0.03	-0.08	0.15	0.06		
DBP	-0.18	-0.09	0.06	0.12	-0.03	-0.12	0.08	0.18	
14-15 (n=215)									
BMI									
WC	0.76								
TC	-0.04	0.11							
LDL-C	0.05	0.20	0.91						
HDL-C	-0.25	-0.26	0.34	-0.01					
TG	0.08	0.20	0.32	0.20	-0.25				
Glucose	0.12	0.09	0.02	0.00	-0.09	0.23			
SBP	0.18	0.15	0.14	0.16	-0.12	0.19	0.07		
DBP	0.04	0.11	-0.01	-0.03	0.02	-0.00	0.15	0.20	
16-17 (n=252)									
BMI									
WC	0.71								
TC	0.12	0.09							
LDL-C	0.13	0.08	0.90						
HDL-C	-0.25	-0.27	0.13	-0.18					
TG	0.33	0.39	0.27	0.13	-0.45				
Glucose	-0.00	0.12	0.10	0.12	-0.01	-0.02			
SBP	0.34	0.14	-0.02	-0.03	-0.18	0.26	-0.11		
DBP	0.06	0.09	-0.02	-0.10	0.07	0.11	-0.08	0.39	
18-19 (n=229)									
BMI									
WC	0.84								
TC	0.25	0.12							
LDL-C	0.23	0.12	0.91						
HDL-C	-0.11	-0.23	0.07	-0.16					
TG	0.19	0.22	0.34	0.08	-0.30				
Glucose	0.25	0.27	0.04	0.09	0.00	-0.12			
SBP	0.40	0.36	0.27	0.26	-0.23	0.28	0.09		
DBP	0.08	0.07	-0.13	-0.13	0.07	-0.08	-0.00	0.10	

BMI: BMI-for-age percentiles; WC: Waist Circumference (cm); TC: Total cholesterol (mg/dL); LDL-C: LDL-cholesterol; HDL-C: HDL-cholesterol; TG: Triglycerides; SBP: Systolic blood pressure percentiles; DBP: Diastolic Blood Pressure Percentiles.

Table 4.25 Correlation between biomarkers related to MS in Adolescent Girls (12-19 years old) by stratified Age: NHANES III, 1988-1994

	BMI	WC	TC	LDL-C	HDL-C	TG	Glucose	SBP	DBP
12-13									
(n=254)									
BMI									
WC	0.82								
TC	-0.06	-0.08							
LDL-C	0.07	0.04	0.89						
HDL-C	-0.28	-0.31	0.36	0.04					
TG	-0.03	0.02	0.26	0.02	-0.19				
Glucose	-0.16	-0.18	0.09	0.04	0.00	0.15			
SBP	0.23	0.22	-0.04	0.01	-0.06	-0.08	0.02		
DBP	0.10	0.15	0.06	0.10	-0.09	0.03	-0.15	0.21	
14-15									
(n=240)									
BMI									
WC	0.77								
TC	-0.02	-0.09							
LDL-C	0.06	0.03	0.91						
HDL-C	-0.38	-0.44	0.25	-0.07					
TG	0.30	0.34	0.24	0.15	-0.42				
Glucose	0.01	0.19	-0.10	-0.11	-0.03	0.06			
SBP	0.41	0.27	-0.01	0.02	-0.15	0.14	-0.02		
DBP	0.11	-0.02	0.01	-0.01	-0.09	0.20	0.07	0.28	
16-17									
(n=270)									
BMI									
WC	0.69								
TC	0.23	0.21							
LDL-C	0.26	0.21	0.95						
HDL-C	-0.16	-0.28	0.05	-0.18					
TG	0.15	0.40	0.30	0.20	-0.45				
Glucose	-0.01	-0.01	-0.04	-0.02	-0.16	0.15			
SBP	0.25	0.24	-0.04	-0.04	-0.06	0.07	0.06		
DBP	-0.01	-0.04	0.08	0.02	0.16	0.03	0.10	0.31	
18-19									
(n=229)									
BMI									
WC	0.84								
TC	-0.06	-0.00							
LDL-C	-0.07	-0.04	0.89						
HDL-C	-0.27	-0.23	0.24	-0.07					
TG	0.31	0.33	0.20	-0.06	-0.29				
Glucose	0.16	0.24	-0.04	0.02	-0.05	-0.12			
SBP	0.29	0.21	-0.01	-0.03	-0.04	0.10	0.07		
DBP	0.07	0.14	0.07	0.06	-0.15	0.20	-0.02	0.47	

BMI: BMI-for-age percentiles; WC: Waist Circumference (cm); TC: Total cholesterol (mg/dL); LDL-C: LDL-cholesterol; HDL-C: HDL-cholesterol; TG: Triglycerides; SBP: Systolic blood pressure percentiles; DBP: Diastolic Blood Pressure Percentiles.

Table 4.26 Correlation between biomarkers related to MS in Adolescent Boys (12-19 years old) Stratified by Sexual Maturation Stage: NHANES III, 1988-1994

	BMI	WC	TC	LDL-C	HDL-C	TG	Glucose	SBP
Tanner stage 4								
(n=183)								
BMI								
WC	0.63							
TC	-0.18	-0.24						
LDL-C	-0.15	-0.16	0.92					
HDL-C	-0.17	-0.36	0.29	-0.01				
TG	0.06	0.14	0.23	0.12	-0.32			
Glucose	-0.02	0.08	0.16	0.19	-0.16	0.20		
SBP	0.19	0.03	0.05	0.02	0.21	-0.04	0.08	
DBP	-0.07	-0.03	0.07	0.10	0.06	-0.16	-0.03	0.35
Tanner stage 5								
(n=512)								
BMI								
WC	0.75							
TC	0.16	0.23						
LDL-C	0.17	0.23	0.93					
HDL-C	-0.18	-0.22	0.17	-0.05				
TG	0.21	0.32	0.40	0.23	-0.36			
Glucose	0.17	0.21	0.10	0.10	-0.01	0.03		
SBP	0.36	0.36	0.25	0.24	-0.24	0.36	0.08	
DBP	-0.05	-0.01	-0.11	-0.13	0.08	-0.07	0.03	0.14
Tanner stage 4 and Tanner Stage 5 (n=695)								
BMI								
WC	0.72							
TC	0.09	0.15						
LDL-C	0.11	0.16	0.92					
HDL-C	-0.21	-0.27	0.20	-0.05				
TG	0.23	0.33	0.36	0.21	-0.37			
Glucose	0.13	0.18	0.09	0.09	-0.04	0.07		
SBP	0.34	0.26	0.18	0.16	-0.15	0.28	0.08	
DBP	-0.00	0.05	-0.05	-0.05	0.02	-0.03	0.01	0.19

BMI: BMI-for-age percentiles; WC: Waist Circumference (cm); TC: Total cholesterol (mg/dL); LDL-C: LDL-cholesterol; HDL-C: HDL-cholesterol; TG: Triglycerides; SBP: Systolic blood pressure percentiles; DBP: Diastolic Blood Pressure Percentiles.

Table 4.27 Correlation between Biomarkers related to MS in Adolescent Girls (12-19 Years old) Stratified by Sexual Maturation Stage: NHANES III, 1988-1994

	BMI	WC	TC	LDL-C	HDL-C	TG	Glucose	SBP
Tanner stage 4 (n=322)								
BMI								
WC	0.79							
TC	-0.08	-0.06						
LDL-C	-0.03	-0.02	0.93					
HDL-C	-0.31	-0.34	0.34	0.11				
TG	0.21	0.27	0.14	0.00	-0.40			
Glucose	0.08	0.04	0.07	0.07	-0.06	0.01		
SBP	0.22	0.17	-0.04	-0.04	-0.18	0.09	0.15	
DBP	-0.10	0.10	0.05	0.10	-0.18	0.15	-0.01	0.22
Tanner stage 5 (n=473)								
BMI								
WC	0.73							
TC	0.03	0.01						
LDL-C	0.08	0.06	0.91					
HDL-C	-0.27	-0.32	0.24	-0.07				
TG	0.21	0.26	0.32	0.14	-0.29			
Glucose	0.01	-0.06	-0.03	-0.01	-0.05	-0.01		
SBP	0.28	0.19	0.02	0.02	-0.01	0.00	0.01	
DBP	0.09	0.04	0.08	0.06	0.00	0.08	0.11	0.28
Tanner stage 4 and Tanner stage 5 (n=795)								
BMI								
WC	0.77							
TC	0.02	0.01						
LDL-C	0.06	0.05	0.92					
HDL-C	-0.28	-0.32	0.23	-0.05				
TG	0.22	0.27	0.27	0.10	-0.34			
Glucose	0.08	-0.01	-0.02	0.01	-0.05	0.00		
SBP	0.25	0.19	0.01	0.02	-0.07	0.05	0.10	
DBP	0.01	0.06	0.05	0.03	-0.05	0.12	0.07	0.28

BMI: BMI-for-age percentiles; WC: Waist Circumference (cm); TC: Total cholesterol (mg/dL); LDL-C: LDL-cholesterol; HDL-C: HDL-cholesterol; TG: Triglycerides; SBP: Systolic blood pressure percentiles; DBP: Diastolic Blood Pressure Percentiles.

Table 4.28 Factor loading matrix for biomarkers related to MS in boys and girls 12-19 years old: NHANES III, 1988-1994

Biomarker	Factor 1	Factor 2	Factor 3	Factor 4*
Total Sample (n=1931)				
Overall #				
BMI	0.383	-0.012	-0.003	-
WC	0.392	-0.018	-0.005	-
TG	0.252	0.105	-0.034	-
HDL-C	-0.325	0.116	0.279	-
LDL-C	-0.008	0.506	0.065	-
Tot-C	-0.052	0.506	-0.001	-
Glucose	-0.003	-0.008	0.279	-
SBP	0.012	0.021	0.516	-
DBP	-0.184	-0.040	0.678	-
Total Sample				
Boys (n=938)†				
BMI	0.348	-0.032	0.019	-
WC	0.367	-0.027	0.025	-
TG	0.251	0.095	0.013	-
HDL-C	-0.326	0.145	0.755	-
LDL-C	-0.013	0.463	0.494	-
Tot-C	-0.054	0.498	0.187	-
Glucose	0.111	0.014	-0.038	-
SBP	0.080	0.059	-0.074	-
DBP	-0.124	-0.074	0.093	-
Total Sample				
Girls (n=993)‡				
BMI	-0.005	0.477	0.006	-0.065
WC	-0.008	0.464	-0.007	-0.019
TG	0.095	-0.017	-0.107	0.527
HDL-C	0.099	-0.070	0.119	-0.527
LDL-C	0.481	0.006	-0.012	0.007
Tot-C	0.508	-0.026	0.002	-0.034
Glucose	-0.056	-0.372	0.355	0.506
SBP	-0.020	0.130	0.553	-0.178
DBP	0.008	-0.074	0.572	-0.020

BMI: BMI-for-age percentiles; WC: Waist Circumference (cm); TC: Total cholesterol (mg/dL); LDL-C: LDL-cholesterol; HDL-C: HDL-cholesterol; TG: Triglycerides; SBP: Systolic blood pressure percentiles; DBP: Diastolic Blood Pressure Percentiles.

* Eigenvalues for factor 4 were not greater than 1 therefore no factor loadings are displayed

- Variance explained for all the factors in each sample: #60%; † 60%; ‡60

Table 4.29 Factor loading matrix for biomarkers related to MS in boys 12-19 years old: NHANES III, 1988-1994

Biomarker	Factor 1	Factor 2	Factor 3	Factor 4*
12-13 (n=242)[#]				
BMI	0.365	0.012	-0.087	-
WC	0.368	-0.001	-0.021	-
TG	0.250	0.093	-0.001	-
HDL-C	-0.249	0.058	-0.109	-
LDL-C	0.035	0.488	-0.002	-
Tot-C	0.020	0.511	-0.045	-
Glucose	0.112	0.088	0.201	-
SBP	0.077	-0.017	0.527	-
DBP	-0.142	-0.070	0.699	-
14-15 (n=215)[†]				
BMI	-0.034	0.520	-0.116	0.005
WC	0.045	0.502	-0.084	0.006
TG	0.119	-0.104	0.585	0.017
HDL-C	0.170	-0.129	-0.466	0.737
LDL-C	0.444	0.045	-0.002	0.404
Tot-C	0.482	-0.039	-0.047	0.208
Glucose	-0.066	-0.150	0.422	-0.061
SBP	0.052	0.037	0.085	-0.062
DBP	-0.068	-0.034	-0.143	0.289
16-17 (n=252)[‡]				
BMI	-0.028	0.438	-0.014	0.085
WC	-0.063	0.522	0.012	-0.019
TG	0.076	-0.023	-0.420	0.063
HDL-C	0.076	0.096	0.617	0.184
LDL-C	0.491	-0.066	-0.053	-0.042
Tot-C	0.523	-0.026	0.081	0.067
Glucose	0.013	0.477	0.351	-0.244
SBP	0.000	-0.027	-0.070	0.489
DBP	0.031	0.011	0.229	0.590
18-19 (n=229)[§]				
BMI	0.396	0.007	-0.012	0.089
WC	0.417	-0.095	0.065	0.009
TG	-0.100	0.304	0.520	0.041
HDL-C	-0.033	0.169	-0.499	0.270
LDL-C	-0.023	0.477	-0.076	-0.064
Tot-C	-0.070	0.514	-0.045	0.044
Glucose	0.402	-0.039	-0.350	-0.352
SBP	0.116	0.086	0.216	0.260
DBP	0.005	-0.011	-0.090	0.825

BMI: BMI-for-age percentiles; WC: Waist Circumference (cm); TC: Total cholesterol (mg/dL); LDL-C: LDL-cholesterol; HDL-C: HDL-cholesterol; TG: Triglycerides;

SBP: Systolic blood pressure percentiles; DBP: Diastolic Blood Pressure Percentiles

* Eigenvalues for factor 4 were not greater than 1 therefore no factor loadings are displayed

- Variance explained for all the factors in each sample: [#]61%; [†] 73%; [‡]75%; [§]75

Table 4.30 Factor loading matrix for biomarkers related to MS in boys at Tanner stage 4, Tanner stage 5 and Tanner stage 4 and 5 combined: NHANES III, 1988-1994

Biomarker	Factor 1	Factor 2	Factor 3	Factor 4
Tanner stage 4 (n=183)[#]				
BMI	0.108	0.596	-0.161	0.004
WC	0.022	0.490	0.049	-0.004
TG	0.095	0.029	0.404	-0.090
HDL-C	0.161	-0.002	-0.494	0.057
LDL-C	0.476	0.062	0.022	-0.032
Tot-C	0.513	0.062	-0.037	-0.029
Glucose	-0.025	-0.164	0.531	0.226
SBP	0.008	0.112	-0.012	0.573
DBP	-0.069	-0.107	0.101	0.583
Tanner stage 5 (n=512)[†]				
BMI	-0.089	0.484	0.001	-0.080
WC	-0.049	0.447	0.042	-0.035
TG	0.120	-0.137	0.448	0.019
HDL-C	0.172	0.085	-0.544	0.137
LDL-C	0.457	-0.042	-0.053	-0.042
Tot-C	0.496	-0.054	-0.071	0.014
Glucose	-0.005	0.416	-0.315	0.026
SBP	0.068	0.027	0.284	0.392
DBP	-0.023	-0.041	-0.050	0.860
Tanner stage 4 and 5 combined (n=695)[‡]				
BMI	-0.073	0.480	-0.001	0.005
WC	-0.041	0.453	-0.048	-0.009
TG	0.133	-0.127	-0.495	0.010
HDL-C	0.129	0.111	0.601	0.083
LDL-C	0.461	-0.032	0.068	0.005
Tot-C	0.492	-0.037	0.009	-0.031
Glucose	0.010	0.454	0.323	-0.115
SBP	0.048	0.023	-0.116	0.492
DBP	-0.051	-0.100	0.136	0.779

BMI: BMI-for-age percentiles; WC: Waist Circumference (cm); TC: Total cholesterol (mg/dL); LDL-C: LDL-cholesterol; HDL-C: HDL-cholesterol; TG: Triglycerides; SBP: Systolic blood pressure percentiles; DBP: Diastolic Blood Pressure Percentiles

- Variance explained for all the factors in each sample: [#]73%; [†] 75%; [‡]73%

Table 4.31 Factor loading matrix for biomarkers related to MS in girls 12-19 years old: NHANES III, 1988-1994

Biomarker	Factor 1	Factor 2	Factor 3	Factor 4
12-13 (n=254)[#]				
BMI	0.460	0.061	-0.091	-0.077
WC	0.457	0.043	-0.052	-0.048
TG	0.059	0.041	0.636	-0.017
HDL-C	-0.251	0.175	-0.392	-0.015
LDL-C	0.074	0.475	-0.010	-0.003
Tot-C	-0.014	0.495	0.042	-0.014
Glucose	-0.123	-0.025	0.485	0.042
SBP	-0.054	-0.042	0.007	0.630
DBP	-0.108	0.015	0.023	0.683
14-15 (n=240)[†]				
BMI	0.319	-0.014	0.101	-0.195
WC	0.330	-0.043	0.088	-0.185
TG	0.263	0.178	-0.108	0.403
HDL-C	-0.417	0.038	0.289	-0.180
LDL-C	0.037	0.471	-0.047	-0.048
Tot-C	-0.073	0.493	0.054	-0.002
Glucose	-0.041	-0.040	0.035	0.725
SBP	-0.026	-0.021	0.565	-0.192
DBP	-0.172	0.021	0.623	0.309
16-17 (n=270)[‡]				
BMI	-0.016	0.491	-0.132	0.001
WC	-0.050	0.465	0.029	-0.036
TG	0.069	0.004	0.447	-0.006
HDL-C	0.090	-0.049	-0.489	0.181
LDL-C	0.481	-0.043	0.001	-0.022
Tot-C	0.507	-0.056	-0.048	0.039
Glucose	-0.024	-0.261	0.482	0.251
SBP	-0.128	0.231	-0.022	0.482
DBP	0.082	-0.113	-0.009	0.645
18-19 (n=229)[§]				
BMI	0.408	-0.005	0.120	-0.042
WC	0.429	0.026	0.097	-0.045
TG	-0.067	0.062	0.560	-0.021
HDL-C	-0.017	0.065	-0.399	0.065
LDL-C	0.037	0.498	-0.032	-0.021
Tot-C	0.003	0.516	0.013	-0.001
Glucose	0.452	0.021	-0.471	-0.010
SBP	0.042	-0.035	-0.152	0.592
DBP	-0.139	0.011	0.041	0.597

BMI: BMI-for-age percentiles; WC: Waist Circumference (cm); TC: Total cholesterol (mg/dL); LDL-C: LDL-cholesterol; HDL-C: HDL-cholesterol; TG: Triglycerides; SBP: Systolic blood pressure percentiles; DBP: Diastolic Blood Pressure Percentiles

- Variance explained for all the factors in each sample: [#]72%; [†] 75%; [‡]76%; [§]76%

Table 4.32 Factor loading matrix for biomarkers related to MS in girls at Tanner stage 4, Tanner stage 5 and Tanner stage 4 and 5 combined: NHANES III, 1988-1994

Biomarker by	Factor 1	Factor 2	Factor 3	Factor 4
Tanner stage 4 (n=322)[#]				
BMI	0.021	0.496	-0.168	0.042
WC	0.037	0.452	-0.028	-0.022
TG	0.085	0.121	0.432	-0.049
HDL-C	0.122	-0.118	-0.356	0.134
LDL-C	0.477	0.032	0.017	0.573
Tot-C	0.500	0.025	0.025	0.021
Glucose	0.020	-0.003	-0.180	0.033
SBP	-0.041	-0.043	0.162	-0.266
DBP	0.027	-0.247	0.576	0.679
Tanner stage 5 (n=473)[†]				
BMI	0.345	-0.024	0.196	-0.168
WC	0.386	-0.029	0.091	-0.199
TG	0.283	0.176	-0.204	0.231
HDL-C	-0.375	0.073	0.261	-0.295
LDL-C	0.003	0.463	-0.018	-0.004
Tot-C	-0.057	0.495	0.023	-0.048
Glucose	-0.010	-0.019	0.043	0.764
SBP	-0.020	-0.040	0.596	-0.099
DBP	-0.080	0.330	0.490	0.350
Tanner stage 4 and 5 combined (n=795)				
BMI	0.001	0.522	-0.086	-0.079
WC	-0.004	0.486	-0.008	-0.099
TG	0.093	-0.122	0.617	0.045
HDL-C	0.119	0.037	-0.594	-0.005
LDL-C	0.478	0.012	0.004	-0.023
Tot-C	0.505	-0.012	-0.033	-0.009
Glucose	-0.037	-0.128	0.107	0.386
SBP	0.005	0.241	-0.277	0.499
DBP	0.019	-0.099	0.062	0.609

BMI: BMI-for-age percentiles; WC: Waist Circumference (cm); TC: Total cholesterol (mg/dL); LDL-C: LDL-cholesterol; HDL-C: HDL-cholesterol; TG: Triglycerides; SBP: Systolic blood pressure percentiles; DBP: Diastolic Blood Pressure Percentiles

- Variance explained for all the factors in each sample: [#]74%; [†] 73%; [‡]72%

Table 4.33 Demographic characteristics of factor loading scores in boys and girls 12-19 years old using NHANES III: 1988-1994

Variable	N	Quartile for Factor 1				Quartile for Factor 2				Quartile for Factor 3			
		Q1 (n=482)	Q2 (n=484)	Q3 (n=483)	Q4 (n=482)	Q1 (n=482)	Q2 (n=484)	Q3 (n=483)	Q4 (n=482)	Q1 (n=483)	Q2 (n=483)	Q3 (n=483)	Q4 (n=482)
		%				%				%			
Age	1931												
12-13	496	32.05	23.76	21.11	23.07	22.20	25.32	31.04	21.44	24.71	24.91	22.33	28.05
14-15	455	26.02	25.45	25.12	23.41	31.37	28.47	21.66	18.50	26.52	29.43	23.71	20.35
16-17	522	17.23	27.24	29.19	26.34	34.44	25.84	18.66	21.06	30.97	26.93	20.19	21.91
18-19	458	23.52	26.23	23.91	26.34	20.84	26.80	23.77	28.59	19.95	21.02	31.56	27.47
Tanner stage													
1	68	49.37	20.08	18.27	12.28	12.78	17.22	33.07	36.92	13.53	36.42	21.53	28.51
2	80	17.23	14.91	31.01	36.85	9.42	19.75	37.55	33.28	41.37	23.60	19.33	15.70
3	168	34.79	21.52	18.65	25.04	11.63	37.61	32.30	18.47	25.93	31.69	26.27	16.11
4	505	27.80	28.87	20.98	22.36	35.52	20.79	25.56	18.13	27.15	27.71	20.09	25.05
5	985	18.81	26.44	28.12	26.63	27.77	28.81	19.60	23.82	25.13	22.47	28.42	23.98
Race/Ethnicity	1931												
Non-Hispanic White	151	21.58	27.03	24.70	26.68	29.51	26.03	22.78	21.67	26.82	24.38	24.09	24.72
Non-Hispanic Black	651	33.21	25.75	22.96	18.08	20.12	23.48	28.16	28.24	22.84	24.73	26.32	26.11
Mexican American	675	20.55	22.69	26.94	29.82	26.60	28.29	22.12	22.99	23.48	23.90	26.80	25.83
Poverty													
Income Ratio[†]	1749												
< 1	624	22.68	29.50	19.18	28.64	24.85	23.97	25.89	25.29	26.74	27.45	24.19	21.61
≥ 1 and < 2	507	22.83	24.42	27.40	25.35	25.80	32.46	22.98	18.75	26.76	27.94	20.12	25.19
> 2	618	26.85	24.25	25.67	23.24	29.30	26.39	22.42	21.90	25.24	24.83	24.77	25.17

Table 4.33 Demographic characteristics of factor loading scores in boys and girls 12-19 years old using NHANES III: 1988-1994 †
(cont'd)

Variable	N	Quartile for Factor 1				Quartile for Factor 2				Quartile for Factor 3			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
		(n=482)	(n=484)	(n=483)	(n=482)	(n=482)	(n=484)	(n=483)	(n=482)	(n=483)	(n=483)	(n=483)	(n=482)
%													
Tobacco Use*													
Smoking	1931												
	189	15.05	30.11	13.41	41.43	24.99	27.70	19.48	27.83	21.65	29.26	21.76	27.33
Not Smoking	1673	25.88	25.49	26.58	22.06	27.93	26.07	24.48	21.52	26.41	24.52	25.31	23.75
Possibly Smoking	69	30.25	15.24	31.13	23.38	24.19	32.74	22.35	20.72	24.54	34.28	13.69	27.49
Physical Activity													
(17-19 years old)	699												
Inactive	64	14.93	19.94	18.90	46.23	24.91	41.55	13.45	20.10	37.89	25.37	23.42	13.32
Moderate	282	19.68	19.53	28.16	32.62	23.47	20.12	21.64	34.77	26.46	25.02	24.23	24.29
Vigorous	353	21.96	27.60	27.50	22.93	27.53	30.72	23.37	18.38	19.58	22.41	29.86	28.15
TV Viewing													
(12-16 years old)	1217												
0-1 hours	303	32.13	26.07	25.60	16.20	28.70	23.51	27.04	20.74	27.35	29.85	23.51	19.29
2-3 hours	401	24.59	29.09	23.01	23.31	29.33	28.12	22.38	20.17	27.17	25.36	20.86	26.60
4-5 hours	444	23.43	23.37	22.03	31.17	28.03	26.58	23.01	22.39	25.90	26.02	24.59	23.49
More than 5 hours	69	28.88	31.77	21.03	18.33	26.27	27.69	27.42	18.61	30.84	17.38	17.18	34.59

* Row percents in each factor adds to 100 ; † n=1931 ; weighted n = 17 746 990

Tobacco Use: Smoking: Self-reported tobacco use and cotinine levels > 15ng/mL: Not Smoking: Self-reported non-tobacco user and cotinine levels ≤ 15 ng/mL: Possibly Smoking: Self-reported non-tobacco user and cotinine levels > 15ng/mL

† Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

Table 4.34 Demographic characteristics of factor loading scores in boys 12-19 years old using NHANES III: 1988-1994[†]

Variable	N	Quartile for Factor 1				Quartile for Factor 2				Quartile for Factor 3			
		Q1 (n=235)	Q2 (n=234)	Q3 (n=234)	Q4 (n=235)	Q1 (n=235)	Q2 (n=234)	Q3 (n=235)	Q4 (n=234)	Q1 (n=235)	Q2 (n=234)	Q3 (n=234)	Q4 (n=235)
%													
Age	938												
12-13	242	34.70	20.35	22.18	22.77	22.52	21.30	32.36	23.81	30.38	23.53	19.76	26.33
14-15	215	25.87	21.83	29.10	23.20	31.77	26.38	24.33	17.52	28.49	33.86	22.02	15.63
16-17	252	16.56	25.52	30.95	26.97	36.84	23.94	21.09	18.12	37.31	24.84	17.90	19.94
18-19	229	12.79	33.77	22.91	30.53	22.89	29.92	21.65	25.55	21.35	16.22	28.47	33.96
%													
Tanner stage	889												
1	61	61.16	7.28	18.59	12.98	11.44	1440	32.98	41.19	28.70	23.93	30.01	17.35
2	46	21.03	15.02	34.40	29.55	2.55	21.66	34.40	41.40	57.39	8.88	19.80	13.93
3	87	33.56	26.16	12.42	27.86	8.55	32.83	44.08	14.54	34.28	39.75	9.53	16.44
4	183	22.80	29.61	27.87	19.72	41.02	20.19	24.01	14.78	33.36	25.36	17.43	23.84
5	512	16.11	26.07	27.54	30.29	29.72	26.78	19.99	23.51	25.98	22.43	26.97	24.61
%													
Race/Ethnicity	938												
Non-Hispanic White	241	18.02	26.13	27.56	28.29	32.03	23.54	23.38	21.05	32.59	23.73	20.11	23.58
Non-Hispanic Black	319	33.60	26.34	25.25	14.82	18.47	24.87	26.76	29.90	21.62	24.06	25.80	28.52
Mexican American	346	22.59	21.58	22.83	33.00	25.26	27.81	23.72	23.21	23.25	25.18	27.22	24.35
Other	32	44.62	19.97	20.00	15.41	17.93	37.79	37.48	6.81	24.71	29.85	24.67	20.78
%													
Poverty	842												
Income Ratio [†]													
< 1	315	23.76	24.36	21.67	30.20	26.11	17.50	28.66	27.73	31.11	20.50	21.12	27.27
≥ 1 and < 2	245	21.25	24.74	25.32	28.69	30.47	31.04	19.38	19.11	34.61	22.49	15.44	27.40
> 2	282	23.14	25.82	26.79	24.26	30.29	26.03	24.91	18.77	30.16	23.08	24.25	22.50

Table 4.34 Demographic characteristics of factor loading scores in boys 12-19 years old using NHANES III: 1988-1994 (cont'd)

Variable	N	Quartile for Factor 1				Quartile for Factor 2				Quartile for Factor 3			
		Q1 (n=235)	Q2 (n=234)	Q3 (n=234)	Q4 (n=235)	Q1 (n=235)	Q2 (n=234)	Q3 (n=235)	Q4 (n=234)	Q1 (n=235)	Q2 (n=234)	Q3 (n=234)	Q4 (n=235)
		%				%				%			
Tobacco Use[#]	938												
Smoking	116	9.80	39.23	17.11	33.86	28.35	27.22	15.04	29.39	28.31	23.19	20.35	28.16
Not Smoking	783	24.19	23.53	27.51	24.77	28.92	24.4	27.07	19.97	29.99	24.48	22.64	22.90
Possibly Smoking	39	38.09	8.03	36.05	17.83	22.53	39.41	21.02	17.04	30.15	26.67	11.36	31.81
Physical Activity (17-19 years old)	346												
Inactive	16	5.66	54.32	1.32	38.70	3.22	74.76	15.65	6.38	40.58	3.15	39.04	17.23
Moderate	104	8.74	20.59	27.41	43.26	26.97	17.28	17.56	38.19	31.86	18.07	15.29	34.77
Vigorous	226	14.46	29.21	30.63	25.70	30.05	30.87	22.17	16.91	24.69	20.03	27.06	28.23
TV Viewing (12-16 years old)	584												
0-1 hours	146	31.82	24.79	25.09	18.31	28.23	19.34	27.89	24.54	36.15	30.18	22.17	11.49
2-3 hours	185	28.07	27.19	25.70	19.03	25.79	29.85	25.56	18.81	27.13	25.81	20.70	26.36
4-5 hours	220	26.4	18.44	23.04	32.11	34.93	19.77	26.09	19.20	31.62	27.56	19.11	21.72
More than 5 hours	33	31.26	21.59	30.57	16.58	19.83	28.45	37.02	14.70	24.60	21.81	10.91	32.07

* Row percents in each factor adds to 100 ; † n=938 ; weighted n = 935 8618

Tobacco Use: Smoking: Self-reported tobacco use and cotinine levels > 15ng/mL: Not Smoking: Self-reported non-tobacco user and cotinine levels ≤ 15 ng/mL: Possibly Smoking: Self-reported non-tobacco user and cotinine levels > 15ng/mL

† Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

Table 4.35 Demographic characteristics of factor loading scores for factor 1 and factor 2 in girls 12-19 years old using NHANES III: 1988-1994[†]

Variable	N	Quartile for Factor 1				Quartile for Factor 2			
		Q1 (n=249)	Q2 (n=248)	Q3 (n=247)	Q4 (n=249)	Q1 (n=248)	Q2 (n=248)	Q3 (n=248)	Q4 (n=249)
		%				%			
Age	993								
12-13	254	25.98	23.06	30.91	20.06	40.46	18.59	22.60	18.34
14-15	240	27.77	32.14	20.18	19.91	30.58	25.85	18.67	24.90
16-17	270	33.47	25.41	16.13	24.98	17.69	29.69	25.88	26.75
18-19	229	17.55	26.22	26.22	30.02	27.69	24.78	27.88	19.65
Tanner stage	917								
1	7	22.23	35.27	19.67	22.84	54.03	0.00	5.79	40.18
2	34	21.85	14.64	31.56	31.95	19.63	11.81	54.44	14.12
3	81	18.33	32.11	24.46	25.10	47.61	21.00	12.86	18.52
4	322	31.93	21.13	26.03	20.92	41.04	16.69	21.27	21.00
5	473	25.57	30.40	19.69	24.34	18.82	30.43	27.22	23.53
Race/Ethnicity	993								
Non-Hispanic White	274	27.80	26.43	23.10	22.67	30.94	25.51	22.13	21.42
Non-Hispanic Black	332	20.73	24.33	25.79	29.14	24.46	24.89	24.26	26.39
Mexican American	329	29.00	27.26	22.29	21.45	19.22	27.75	27.10	25.92
Other	58	23.04	32.56	19.59	24.81	28.74	19.81	29.46	21.98
Poverty Income Ratio†	907								
<1	309	21.82	31.98	23.78	22.43	23.81	24.34	22.99	28.86
≥1 and <2	262	23.07	32.69	24.27	19.98	27.55	23.01	23.29	26.15
>2	336	29.16	23.57	22.05	25.22	32.54	26.01	23.38	18.07

Table 4.35 Demographic characteristics of factor loading scores for factor 1 and factor 2 in girls 12-19 years old using NHANES III: 1988-1994 (cont'd)

Variable	N	Quartile for Factor 1				Quartile for Factor 2			
		Q1 (n=249)	Q2 (n=248)	Q3 (n=247)	Q4 (n=249)	Q1 (n=248)	Q2 (n=248)	Q3 (n=248)	Q4 (n=249)
				%				%	
Tobacco Use[#]	993								
Smoking	73	17.12	28.46	26.25	28.18	18.93	21.15	18.67	41.25
Not Smoking	890	27.33	26.96	21.79	23.91	30.80	25.97	23.74	19.49
Possibly Smoking	30	33.25	20.74	38.09	7.92	16.32	16.13	37.93	29.62
Physical Activity (17-19 years old)	353								
Inactive	48	32.80	29.74	13.90	23.56	7.16	14.94	23.10	54.81
Moderate	178	19.72	24.99	25.68	29.61	24.23	25.05	30.50	20.22
Vigorous	127	26.69	27.29	24.80	21.23	28.79	23.82	29.44	17.95
TV Viewing (12-16 years old)	633								
0-1 hours	157	27.71	27.27	23.42	21.59	34.04	29.34	16.58	20.04
2-3 hours	216	31.65	27.31	18.12	22.91	31.70	25.45	23.89	19.04
4-5 hours	224	22.24	27.44	23.93	26.39	28.01	19.68	23.22	29.10
More than 5 hours	36	32.61	27.06	30.66	9.66	33.53	27.56	16.16	22.74

* Row percents in each factor adds to 100 : † n=993 ; weighted n = 8388372

Tobacco Use: Smoking: Self-reported tobacco use and cotinine levels > 15ng/mL; Not Smoking: Self-reported non-tobacco user and cotinine levels ≤ 15 ng/mL; Possibly Smoking: Self-reported non-tobacco user and cotinine levels > 15ng/mL

† Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

Table 4.35 Demographic characteristics of factor loading scores for factor 3 and factor 4 in girls 12-19 years old using NHANES III: 1988-1994 (cont'd)[†]

Variable	N	Quartile for Factor 3				Quartile for Factor 4			
		Q1 (n=249)	Q2 (n=248)	Q3 (n=248)	Q4 (n=248)	Q1 (n=249)	Q2 (n=247)	Q3 (n=249)	Q4 (n=248)
		%				%			
Age	993								
12-13	254	25.59	20.93	29.02	24.46	16.04	31.03	25.21	27.72
14-15	240	22.24	29.89	22.74	25.13	19.95	24.46	27.52	28.08
16-17	270	26.24	31.52	22.34	19.90	22.49	26.87	25.87	24.76
18-19	229	21.68	32.26	22.33	23.73	28.98	20.93	23.14	26.94
Tanner stage	917								
1	7	22.84	53.11	22.23	1.83	53.11	0.00	22.84	24.06
2	34	20.61	32.81	41.91	4.67	8.95	14.06	28.54	48.45
3	81	25.74	22.73	28.31	23.21	9.06	29.43	16.41	45.10
4	322	23.66	27.59	24.39	24.36	20.21	31.15	25.53	23.12
5	473	23.87	31.07	23.23	21.83	24.85	20.49	28.00	26.65
Race/Ethnicity	993								
Non-Hispanic White	274	25.37	28.22	23.66	22.75	19.26	25.27	25.04	30.43
Non-Hispanic Black	332	22.13	25.47	25.09	27.31	37.94	26.05	23.47	12.54
Mexican American	329	26.82	20.66	27.48	25.05	22.21	22.39	27.60	27.80
Other	58	15.52	43.43	21.35	19.69	16.56	30.02	29.06	24.36
Poverty Income Ratio[†]	907								
< 1	309	21.18	35.18	27.15	16.49	21.29	23.24	25.02	30.44
≥ 1 and < 2	262	19.31	32.77	24.18	23.74	23.98	26.00	28.22	21.80
> 2	336	25.30	25.58	23.51	25.61	21.01	26.07	24.87	28.05

Table 4.35 Demographic characteristics of factor loading scores for factor 3 and factor 4 in girls 12-19 years old using NHANES III: 1988-1994 (cont'd)

Variable	N	Quartile for Factor 3				Quartile for Factor 4			
		Q1 (n=249)	Q2 (n=248)	Q3 (n=248)	Q4 (n=248)	Q1 (n=249)	Q2 (n=247)	Q3 (n=249)	Q4 (n=248)
		%				%			
Tobacco Use[#]	993								
Smoking	73	28.78	34.35	19.81	17.06	14.29	18.98	19.05	47.68
Not Smoking	890	23.60	27.49	24.41	24.50	23.01	26.97	26.26	23.76
Possibly Smoking	30	15.13	40.93	26.69	17.25	24.33	19.85	29.09	26.73
Physical Activity (17-19 years)	353								
Inactive	48	24.04	32.98	28.34	14.64	8.24	38.96	12.45	40.35
Moderate	178	27.93	33.20	19.18	19.69	20.06	24.97	21.60	32.83
Vigorous	127	17.60	32.02	21.84	28.54	37.73	19.74	23.45	19.08
TV Viewing (12-16 years)	633								
0-1 hours	157	19.60	30.00	21.71	28.69	25.68	30.97	27.12	16.22
2-3 hours	216	31.40	27.55	22.61	18.44	9.43	24.07	31.11	35.39
4-5 hours	224	22.84	22.12	32.10	22.94	19.58	25.40	23.41	31.62
More than 5 hours	36	21.94	22.35	30.56	25.14	24.68	25.13	11.48	12.31

* Row percents in each factor adds to 100; † n=993; weighted n = 8388372

Tobacco Use: Smoking: Self-reported tobacco use and cotinine levels > 15ng/mL; Not Smoking: Self-reported non-tobacco user and cotinine levels ≤ 15 ng/mL; Possibly Smoking: Self-reported non-tobacco user and cotinine levels > 15ng/mL

‡ Poverty Income Ratio, was the ratio of the reported family incomes divided by the poverty threshold, which was produced annually by the Census Bureau and adjusted for changes caused by inflation. <1: Reported no income

Chapter 5: Discussion and Conclusion

This study utilized data from NHANES III (1988-1994) to examine the distribution and determine the prevalence of elevated biomarkers related to MS in boys and girls 12-19 years by age and sexual maturation stage within gender, race/ethnicity and poverty income ratio, and to examine the clustering of these biomarkers that have previously been associated with Metabolic Syndrome in adults, in boys and girls 12-19 years, using factor analysis.

To our knowledge, this is the first study to estimate the clustering of biomarkers related to Metabolic Syndrome (MS) using factor analysis in a nationally representative sample in adolescents. Elevated levels of these identified clusters of biomarkers in a population representative of the general population of adolescents, may describe early markers of risk for MS and thus potentially help to identify adolescents to target for early interventions in other populations. Findings from this study suggests that the presence of MS in adolescents, which is similar as MS in adults, further accentuates the need for prevention and interventions to take place early in life rather than in adulthood.

5.1 Comparisons of findings to the literature

In the section below we summarize our findings for each of the Aims in our study and compare these findings to the existing literature

5.1.1 Distribution of biomarkers related to MS by age

*Aim 1: To examine the distribution and determine the prevalence of biomarkers related to Metabolic Syndrome in boys and girls 12-19 years **by age** within gender, race/ethnicity and poverty income ratio.*

These results provide reference data on the distribution of biomarkers related to MS in boys and girls 12-19 years old by age, and by age within race/ethnic group and poverty income ratio for the years 1988-1994. We are aware of only one population-based study that has described the distribution of several specific biomarkers (HDL-cholesterol, LDL-cholesterol, total cholesterol and triglycerides) related to MS by age in a similar way as we did (14). These authors used the same dataset we used but grouped their ages slightly different than we did and also had a somewhat different sample due to different exclusions. Therefore, we expected similar results as in their study to appear in our study. Future studies may compare their results to this data, since our results are representative of the general US adolescent population.

Overall Age

The distribution of biomarkers related to MS in boys and girls by overall age varied depending on the biomarker studied. Our main findings related to the distribution of biomarkers related to MS in boys and girls were that overall triglycerides, total cholesterol, LDL-cholesterol, glucose, systolic blood pressure percentiles and diastolic blood pressure percentiles did not differ considerably by age, and no linear trend was found among these variables by age. These results (which include triglycerides, total cholesterol and LDL-cholesterol) are comparable to findings by Hickman et al. using the same NHANES III population, but slightly different age groupings (14). We noted that

BMI-for-age percentiles decreased by age for boys 18-19 years and slightly for girls of the same age. Given that BMI-for age percentiles were already standardized for age, we did not expect to see large variation for this biomarker. Waist circumference levels increased by age for both boys and girls, but more so for boys. One cross-sectional study conducted on 5-17 year old children and adolescents had similar findings for waist circumference levels by age for boys (12-17 years) (128), but girls in our study had higher median waist circumference levels. This study however, was conducted in a bi-racial rural community that was relatively poor and poverty has been associated with higher BMI and waist circumference, and therefore their results are not generalizable to the US population. Our study also showed that HDL-cholesterol levels decreased by age in boys and increased by age in girls, again consistent with findings obtained by Hickman et al. using the same population (14). To our knowledge, this study is the first to estimate the distribution of BMI-for-age, waist circumference, systolic blood pressure percentiles, diastolic blood pressure percentiles and glucose levels by age in the general US adolescent population, though similar studies have been done in sub-populations (166).

Age within Race/Ethnic Group

Our findings of patterns of biomarkers related to growth in non-Hispanic white, non-Hispanic black and Mexican American boys were also similar to the reported literature. In our study Mexican American boys were more likely to have higher median percentile levels by age on the BMI-for-age growth charts compared to both non-Hispanic white boys and non-Hispanic black boys. Non-Hispanic black girls, however, were more likely to have higher median percentile levels by age on the BMI-for-age growth charts compared to both non-Hispanic white girls and Mexican American girls.

Overall, girls had higher median percentiles on the BMI-for-age growth charts than boys. Other studies that have used similar data (NHANES III and NHANES IV) have identified the same patterns in terms of race/ethnic group when they examined the prevalence of overweight (based on same BMI-for-age percentiles), and trends in overweight for children and adolescents in the US population (2, 21). The NHLBI Growth and Health study also indicated that non-Hispanic black girls at age 9 had a 37% higher overweight prevalence compared to non-Hispanic white girls (166). Waist circumference levels in our study were similar to BMI-for-age percentiles, in that Mexican American boys and non-Hispanic black girls had the highest levels among race/ethnic groups.

The report from the NCEP Expert Panel on blood cholesterol levels in children and adolescents stated that recommended levels for normal total cholesterol is <170 mg/dL and recommended levels for LDL-cholesterol levels is < 110 mg/dL in all children and adolescents in the US (52). The median total cholesterol levels by age within race/ethnic group in our study were generally within normal ranges across all ages, with a few exceptions in non-Hispanic black boys and girls. Non-Hispanic black boys and girls had higher values of total cholesterol, HDL-cholesterol and LDL-cholesterol at all ages compared to non-Hispanic white and Mexican American boys and girls. Among non-Hispanic black boys 12-13 years old, the median total cholesterol levels were 175 mg/dL and for non-Hispanic black girls, 18-19 years the median total cholesterol levels was 172 mg/dL. Hickman et al. found similar results (14).

The median LDL-cholesterol levels in our study were all well within the accepted recommendation of < 110 mg/dL among boys and girls. These findings were supported by Hickman et al. (14). Hickman et al. (14) and Freedman et al. (167) both found that

non-Hispanic black boys and girls had higher levels of total cholesterol, LDL-cholesterol and HDL-cholesterol compared to Mexican American and non-Hispanic white boys and girls. The study population used by Freedman et al. is similar as mentioned above, in that they came from a bi-racial poorer community in Louisiana. In contrast to the latter results, triglyceride levels in our study as well as in Hickman's study were higher among non-Hispanic white and Mexican American boys and girls compared to non-Hispanic black boys and girls (14).

Among race/ethnic group, glucose levels, systolic and diastolic blood pressure percentiles did not vary a great deal by age. Non-Hispanic white and Mexican American boys and girls had slightly higher median glucose levels compared to non-Hispanic black girls and boys, but levels remained relatively constant throughout 12-19 years. Among boys, non-Hispanic black and Mexican American boys had somewhat higher median systolic blood pressure percentiles, and among girls non-Hispanic black girls had slightly higher median systolic blood pressure percentiles.

Age within Poverty income ratio

We examined the distribution of biomarkers related to MS by age within poverty income ratio and found that the biomarkers did not vary considerably. However, we saw some variation by body size characteristics and total cholesterol levels. BMI-for-age percentiles and waist circumference levels among girls tended to increase as poverty income ratio decreased. Trends among boys were not as significant. Among both boys and girls total cholesterol levels were significantly inversely associated with poverty income ratio. We saw little variation or linear trend, however, by age within poverty income ratio for triglycerides, LDL-cholesterol, glucose, systolic blood pressure

percentiles and diastolic blood pressure percentiles in both boys and girls. To our knowledge, there is currently no other literature available that describes the distribution of biomarkers related to MS by age within poverty income ratio for comparison of findings.

5.1.2 Prevalence of Elevated Levels of Biomarkers by Age

In the second analyses of aim 1 we presented the prevalence estimates of elevated levels of biomarkers related to MS in boys and girls 12-19 years old by age. Cook et al. also presented prevalence estimates of individual biomarkers related to MS in boys and girls 12-19 years old using data from NHANES III (1988-1994) (1). A limitation to their study was that they did not stratify or adjust for age, which makes it difficult to determine if these biomarkers fluctuated by age in adolescents. In our study we found that boys were more likely to be at risk for overweight at younger ages (12-13 years) and girls were more likely to be at risk for overweight between ages 14-17. Similar to Cook et al. (1), we also saw that elevated triglyceride levels (≥ 110 mg/dL) and low HDL-cholesterol levels (≤ 40 mg/dL) were the most prevalent across all age groups, and elevated glucose levels (≥ 110 mg/dL) and systolic and diastolic blood pressure percentiles ($\geq 90^{\text{th}}$ percentile) were the least prevalent. Our findings for elevated C-reactive protein levels were similar to those of Ford et al. (15) (who used NHANES IV data) and Visser et al. (114) (who used NHANES III data), where girls were more likely to have elevated levels compared to boys with increasing age (for example in our study 20.25% of girls 18-19 years had elevated levels vs. 7.95% of 18-19 year old boys). Visser et al. also determined

that in children 8-16 years old elevated C-reactive protein levels were present in 7.1% of boys and 6.1% of girls in the population (114).

5.1.3 Distribution of Biomarkers related to MS by Tanner stage

Aim 2: To examine the distribution of biomarkers related to MS in boys and girls 12-19 years by sexual maturation stage within gender, race/ethnicity and poverty income ratio.

Our results provide data on the distribution of biomarkers related to MS in boys and girls 12-19 years old by sexual maturation stage. We are not aware of any other studies that have estimated the distribution of biomarkers related to MS by sexual maturation stage, or Tanner stage in particular, in the general US adolescent population, and few studies have estimated the relationship between biomarkers related to MS with pubertal development in children and adolescents in other populations (46, 49, 50, 168).

We also know of no other population-based studies that examined the distribution of biomarkers related to MS by Tanner stage within race/ethnic group and poverty income ratio in a nationally representative sample. We believe it is important to examine biomarkers related to MS by Tanner stage because various studies have shown that levels of biomarkers (e.g. BMI, fasting insulin, and total cholesterol levels) that are related to MS can be influenced by pubertal stage of development (48-50). Early puberty has been shown to be related to earlier occurrence of hyperinsulinemia, for example, that could possibly lead to an increased risk for the development of type 2 diabetes (169).

Overall Tanner stage

We found no substantial differences by Tanner stage for each biomarker related to MS in boys and girls. This could be due to the small sample sizes in Tanner stage 1, Tanner stage 2 and Tanner stage 3, since the majority of our sample was in Tanner stage 4 and Tanner stage 5. As such, the majority of these subjects were likely to have reached mature pubertal status. However, in our study we did see that total cholesterol levels were decreased slightly in boys by Tanner stage, but not in girls. Results from the Bogalusa Heart Study and other studies showed that total cholesterol levels in boys decreased markedly with increasing Tanner stage (49, 50, 168, 170). Our results obtained for triglyceride levels were not consistent with other smaller population studies in terms of pubertal development. We did not see any linear trend for triglyceride levels by Tanner stage. In a Finnish study in children (3-18 years old), triglyceride levels in boys increased with increasing Tanner stage (50). HDL-cholesterol levels in boys decreased with increasing Tanner stage, and in girls HDL-cholesterol levels increased with increasing Tanner stage. This finding was consistent with findings from the Bogalusa Heart Study (50).

Tanner stage within Race/Ethnic Group

Patterns of the distribution of biomarkers related to MS by Tanner stage did not vary substantially by race/ethnic group and thus were similar to patterns observed for overall Tanner stage. Overall, non-Hispanic white boys and Mexican American boys were more likely to have higher median values of triglycerides and waist circumference levels, as well as lower levels of HDL-cholesterol. Among girls, however, Mexican Americans were more likely to have higher median values of triglycerides and waist

circumference among all sexual maturation stages. In contrast to these results, non-Hispanic black boys and girls were more likely to have higher median values of total cholesterol levels compared to Mexican American and non-Hispanic white boys and girls. No linear trend by Tanner stage was seen for glucose, systolic and diastolic blood pressure percentiles.

Tanner stage within poverty income ratio

In contrast to the distribution of biomarkers related to MS within poverty index ratio by age, the distribution of biomarkers within poverty income ratio by Tanner stage did differ to some extent by each Tanner stage in boys and girls. Girls with a poverty income ratio less than one tended to have higher BMI-for-age percentiles on the BMI-for-age growth charts compared to girls with a poverty income ratio greater and equal to two at Tanner stage 3, 4 and 5. Boys and girls with a poverty income ratio less than one had higher waist circumference levels compared to boys and girls with a poverty income ratio greater than and equal to two at all Tanner stages. Only boys with a poverty income ratio less than one had higher total cholesterol levels and higher systolic blood pressure percentiles compared to boys with a poverty income ratio greater than and equal to two at Tanner stage 1,3,4 and 5 for total cholesterol and at Tanner stage 1,2,4 and 5 for systolic blood pressure percentiles. We are not aware of any studies that have examined the distribution of biomarkers related to MS by Tanner stage within poverty income ratio.

5.1.4 Prevalence estimates of elevated levels of biomarkers by Tanner stage

As mentioned previously, to our knowledge no other studies have examined the prevalence of elevated levels of biomarkers related to MS by sexual maturation stage in a

population-based sample like NHANES III. Prevalence estimates of elevated levels of biomarkers related to MS in boys and girls were higher at Tanner stage 2 for both boys and girls, and higher at Tanner stage 5 for boys and Tanner stage 3 for girls. Boys in Tanner stage 2 were most likely to have elevated levels of waist circumference levels, triglyceride levels, and total cholesterol levels. They were also more likely to be at risk for overweight. Boys in Tanner stage 5 were more likely to have low levels of HDL-cholesterol, high levels of LDL-cholesterol and high normal systolic blood pressure. Prevalence estimates of C-reactive protein levels were highest among boys in Tanner stage 3. Girls were more likely to have elevated levels of biomarkers related to MS (overweight, high waist circumference, high triglyceride levels, low HDL-cholesterol levels and high total cholesterol levels), at Tanner stage 3. Similar to boys, girls in Tanner stage 2 were more likely to be at risk for overweight and have high levels of C-reactive protein.

5.1.5 Clustering of biomarkers related to MS and their association with demographic characteristics

Aim3: To examine the clustering of biomarkers that have previously been associated with Metabolic Syndrome in adults, in boys and girls 12-19 years using factor analysis, and the association between demographic variables and these identified factor scores.

Again, this is the first study to have demonstrated the clustering of biomarkers related to MS in adolescents 12-19 years old in a nationally representative sample using factor analysis. This factor analysis approach has been extensively used in adults to determine the clustering of biomarkers related to MS (40, 43). A recent study by Ford et

al defined MS by using factor analysis in the NHANES III adult population and found that regardless of age, sex or race/ethnic group, levels of waist circumference, fasting insulin, triglycerides, and HDL-cholesterol clustered together in one factor (171). This study verifies that this approach may be valuable to identify clusters of biomarkers related to MS among adolescents in a nationally representative sample that could be applied to other populations and used to identify children at risk for the development of Type 2 diabetes (40).

In our analyses correlations between biomarkers for girls and boys were similar which allowed us to combine boys and girls in our factor analysis procedure. We then stratified by gender, age and Tanner stage and found that by age and Tanner stage factors were not meaningful due to a small sample sizes in each group. Therefore we believe that the combined analyses produced the most stable factors.

From our results we can conclude that MS, as defined by the NCEP criteria for adults (157), was not identifiable as a prevalent factor in these adolescents, i.e. the biomarkers did not group similarly as they would group in adults according to the NCEP criteria. Blood pressure and glucose also were not part of the clustering of biomarkers in adolescents. We did, however, identify interpretable clusters of biomarkers related to MS – particularly in our overall sample and in our sample of boys. In our findings, factor one of the overall sample (boys and girls) and factor one of the total sample in boys were similar and the most comparable to the definition of adult MS. This factor loaded high on BMI-for-age percentiles, waist circumference and high but negative on HDL-cholesterol levels. It also loaded somewhat high on triglyceride levels. The clustering of these biomarkers in different forms allows us to conclude that a subset of children was at

risk for elevated levels of this particular clustering of biomarkers when this study was conducted. Factor 2 in the overall sample and the total sample for boys as well as factor 1 in the total sample for girls loaded high on LDL-cholesterol and total cholesterol. Factor 3 in the total sample for boys loaded high on HDL-cholesterol and LDL-cholesterol. From these factors we can conclude that the cholesterol biomarkers are highly derived from one another. Factor 3 in the overall sample loaded high on systolic and diastolic blood pressure, and factor 3 in the total sample for girls loaded high on glucose, systolic blood pressure and diastolic blood pressure. Factor 4 in girls loaded high on triglycerides and high but negative on HDL-cholesterol. Glucose did not load onto any factors in boys, but was present in girls in three factors, but as we have mentioned before, glucose levels did not vary much in the distribution by age and Tanner stage, and the range overall was fairly small too.

Our results differ slightly from the only other study we are aware of that used factor analysis to determine the clustering of variables and their relationship to MS in adolescents (53). Chen et al. examined a biracial population of children (5-11 years), adolescents (12-17 years) and young adults (18-38 years), in the Bogalusa Heart Study. In their analyses adjusted for age and sex, they identified two factors. The first was characterized by: hyperinsulinemia/insulin resistance, dyslipidemia, and obesity and the second by hypertension (systolic blood pressure and diastolic blood pressure). These investigators utilized a larger sample size ($n=4522$) relative to the sample size in our study ($n=1931$). Another study in Sweden examining biomarkers related to MS in adolescents (14 and 17 year olds) using partial correlation analysis, but not factor analysis, concluded that in the subset of adolescents with high BMI ($> 30 \text{ kg/m}^2$), high

serum insulin, triglycerides, LDL-cholesterol and systolic blood pressure and low HDL-cholesterol levels clustered together. They also examined the clustering of biomarkers stratified by insulin quartiles, and didn't find any significant differences in the clustering in the clustering of biomarkers when stratifying by insulin (55).

Demographic characteristics of factor loading scores

In further analyses we divided each factor into quartiles to examine the association of the factor scores in each factor with demographic characteristics. Adolescents in the highest quartile of factor 1 in the overall sample and factor 1 in the total sample for boys were more like to be Mexican American and have less healthy habits in terms of smoking, physical activity and television watching. Adolescents in the highest quartile of factor 2 in the overall sample and the total sample for boys, had similar health habits to the previous factor, but were more likely to be non-Hispanic black. Similar results were found for girls in the highest quartile of factor 1. Adolescents in the highest quartile of factor 3 in the overall sample for boys, and girls in the highest quartile of factor 3 both loaded high on systolic and diastolic blood pressure but had different demographic characteristics. Girls in the highest quartile of factor 3 had healthier habits compared to adolescents in the overall sample. Girls in the highest quartile of factor 2 who had higher BMI-for age percentiles and higher waist circumference levels were more likely to be smokers, have inactive physical activity levels and watch television for 4-5 hours per day. Girls in the highest quartile of factor 4 had similar health habits compared to girls in factor 3. Overall factors did not vary substantially by age, Tanner stage and poverty index ratio. Results in terms of race/ethnic group and poverty income ratio as well as age and Tanner stage were consistent with

results obtained in Aim 1 and Aim 2. For example, in Aim 1 and Aim 2 we found that non-Hispanic black boys and girls were more likely to have higher total cholesterol, LDL-cholesterol and HDL-cholesterol levels compared to the other race/ethnic groups. In Aim 3 we concluded that non-Hispanic black adolescents were more likely to be in the highest quartile of factors that all loaded high on total cholesterol and LDL-cholesterol levels.

5.2 Conclusion

In summary, this study examined the distribution and clustering of biomarkers related to MS, as well as determined the prevalence of elevated biomarkers related to MS by age and Tanner stage in a nationally representative sample. Our major findings related to our first objectives (Aims 1 and 2) were that the distribution and prevalence of elevated levels of biomarkers differed by age and by Tanner stage, within gender, depending on the biomarker under study, though there were few biomarkers that increased or decreased in either a linear or curvilinear manner by age or Tanner stage. The distribution of some of the biomarkers did, however, differ between non-Hispanic whites, non-Hispanic blacks and Mexican Americans where for example non-Hispanic white and Mexican American boys and girls were more likely to have higher levels of triglycerides and lower levels of HDL-cholesterol compared to non-Hispanic blacks. Overall, there were fewer differences in distributions or prevalences of elevated levels of biomarkers between age and Tanner stage within poverty income ratio. These findings point out that adolescents may be at risk for elevated levels of biomarkers related to MS at different ages and

maturation stages and also depending on their race/ethnic group and somewhat on their poverty income ratio status.

We then examined correlations and clusters of biomarkers using factor analyses. In these analyses we found that correlations of biomarkers related to MS were remarkably similar in boys and in girls by age and Tanner stage. We then combined boys and girls in the factor analysis procedure. We also stratified by gender, since boys and girls are shown to be biologically different at this stage in life. We identified 3 factors in the overall sample for boys and girls from this approach (Factor 1: BMI-for-age percentiles, waist circumference levels, triglyceride levels and HDL-cholesterol levels; Factor 2: total cholesterol levels and LDL-cholesterol levels; Factor 3: systolic and diastolic blood pressure percentiles).

In the total sample for boys we identified 3 factors that were somewhat similar to factors in the overall sample for boys and girls (Factor 1: BMI-for-age percentiles, waist circumference levels, triglyceride levels and HDL-cholesterol levels; Factor 2: LDL-cholesterol and total cholesterol; Factor 3: HDL-cholesterol and LDL-cholesterol). Last, we identified 4 factors in the total sample for girls (Factor 1: LDL-cholesterol and total cholesterol; Factor 2: BMI-for-age percentiles, waist circumference levels and negative glucose levels; Factor 3: Glucose, systolic and diastolic blood pressure percentiles; Factor 4: Triglycerides, Glucose and HDL-cholesterol)

These factors suggest that specific subsets of biomarkers associated with MS occur in adolescents. In addition, these data provide the first insight into the clustering of specific biomarkers related to MS in adolescents in a nationally representative sample. According to the NCEP ATP III definition of MS in adults, not all biomarkers are equally predictive

of developing MS, as found by a population-based study in adults (NHANES III) (3). Therefore in our study, even the subsets of biomarkers that clustered may still put these adolescents at risk to develop MS. Like obesity, MS could emerge as a critical risk factor for chronic diseases in adolescents. It is therefore necessary to understand clusters of biomarkers related to MS in children and adolescents in our population.

5.3 Strengths and Limitations of Data Sources and Methods

There are several important considerations that we have to take into account when interpreting the results of this study. The strengths are that this is a population-based study that is representative of the general US adolescent population, and therefore the results obtained are generalizable. The response rate of the whole NHANES III study population study was 86% which is considered to be very high for such a nationwide cross-sectional study. This study is also significant in that no other studies have examined the clustering of biomarkers related to MS in a nationally representative sample using factor analysis or somehow identifying clusters of specific markers. Furthermore, all measurements that were collected in NHANES III were rigorously collected according to standardized procedures in a clinical setting by trained staff and physicians.

The limitations of the present study must also be considered. This study utilized cross-sectional data, i.e. the data was collected at one point in time. We, therefore, cannot make causal inferences from this data. However, this is a national study and the results obtained from this study will provide a baseline to monitor trends in biomarkers related to MS in adolescents in the USA. Another potential limitation to our study was that the

NCEP Adult Treatment Panel recommendations include only examinees who have fasted for 9 hours or more (157).

In addition, selection bias could have resulted from our study since we excluded adolescents who did not fast for 6 hours or more, who had tanner stage variables missing, or had other missing biomarker data. However, we did compare demographic characteristics of adolescents who were missing from our study, to adolescents who had complete data, and they did not differ on age, tanner stage, race/ethnic group, poverty income ratio, smoking status or physical activity. Potential measurement error could also have occurred, since we included participants who fasted for 6 hours or more in our sample, though including only those who fasted for 9 hours is optimally recommend. We did compare biomarkers of those who fasted 6-9 hours to those who fasted 9 hours plus, and since values were similar we didn't want to include additional selection bias by excluding these participants. A further limitation in our study was that when stratifying by age and Tanner stage, we believe sample sizes became too small to obtain stable factor analysis results.

A valuable contribution to the biomarkers we would have liked to include in our study would have been plasma insulin levels, since previous studies have shown that elevated plasma insulin levels have been a strong component of MS (43, 48, 53, 172) and the previous study (53) that examined the clustering of biomarkers related to MS using factor analysis in adolescents, included insulin levels and observed it to be an important component of the MS related factor. Insulin is known to play a very important role in the mechanism of MS.

Furthermore, several of the covariates used in this study, (poverty income ratio, physical activity measurements and television watching) also had some limitations to this data. Many participants did not report their income for unknown reasons and those who didn't report may have been different, thus potentially introducing some selection bias. In addition, different measures of physical activity were available by age. Physical activity was measured only in adults 17 years and older, and television watching was measured only in children and adolescents younger than 17 years. It would have been interesting to look at the association between the identified factors and the above mentioned characteristics in the adolescents who did not have these variables measured.

5.4 Implications of Findings

Since this data is representative of the general population, these results provide reference values for future studies, in the distribution and clustering of biomarkers related to MS as well as the prevalence of elevated levels of biomarkers related to MS. Furthermore, future analyses of NHANES IV or studies could use these results as baseline measures to compare this cross-sectional sample (1988-1994) to what has occurred more recently (1999-2004). Interesting results might come from such an approach since overweight has increased significantly in US adolescents since NHANES III (2) and overweight is also related to MS. The prevalence of risk factors may have increased and clusters of patterns may have changed and potentially appear more similar to adult patterns. Our results are also significant in that we incorporated information on sexual maturation stage, race/ethnic group and poverty income ratio in all our analyses to

determine what impact these covariates may have on the biomarkers related to MS in adolescents.

Due to the increase in overweight in youth further studies may find similar factors as we did, and they may also find adult MS at a younger age due to this increase in overweight. From our results we can also conclude that the clusters that we obtained from each factor especially in the overall sample (boys and girls) and the total sample for boys, may possibly be seen as early predictors of “pre-metabolic syndrome”, and can be used to monitor adolescents at risk for further increased levels.

5.5 Suggestions for future research

The results obtained from our study sets the ground work for future studies to build on. Future studies should aim for a larger sample size in order to produce stable estimates to allow for stratification by age, Tanner stage and potentially race/ethnicity and poverty income ratio in the factor analysis procedure. Future studies are also needed to determine the effect of diet and physical activity on the clustering of risk factors related to MS in adolescents.

It would be ideal if further prospective epidemiological studies could be conducted in order to follow children and adolescents over time. This will enable us to determine if the biomarkers that clustered at this point in time will cluster differently at different ages. In addition, longitudinal studies of children and adolescents are important to see if these clusters of biomarkers in children predict the development of type 2 diabetes, cardiovascular disease or cancer, since all of them have been shown to be related to MS. In addition, since our sample size by overweight status was too small,

future studies should stratify by overweight status ($\geq 90^{\text{th}}$ percentile for age on the BMI-for-age growth charts) in their factor analysis procedure to determine whether these children and adolescents have a higher risk to develop MS.

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