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Prevalence of Premetabolic Syndrome among Non-Hispanic Blacks in the US

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Abstract

Introduction: Metabolic Syndrome (MetS)**,** characterized by high blood pressure, central obesity, high blood glucose, low HDL cholesterol, and high triglycerides, increases the risk of cardiovascular disease and type 2 diabetes, which are major health issues for African Americans. Pre-metabolic Syndrome (PreMetS) offers a critical window for intervention to prevent MetS. This study estimated PreMetS prevalence among non-Hispanic Black adults, exploring differences by sex and other factors.

Methods: Data from the NHANES 2017-2020 cycle were used, defining PreMetS as the presence of two of the following risk factors: high blood pressure, central obesity, elevated blood glucose, low HDL cholesterol, and high triglycerides.

Findings: The prevalence of PreMetS was 40.4% among non-Hispanic Black adults, with a higher prevalence in women (58%) compared to men (42%). Additionally, PreMetS was more common in individuals aged 40 and older. Men had higher rates of elevated triglycerides (27.6% vs. 17.5%) and high blood glucose (34.0% vs. 20.4%), while women had higher rates of low HDL cholesterol (20.4% vs. 27.6%) and abdominal obesity (62.5% vs. 27.6%). BMI was significantly associated with PreMetS risk in women, with higher odds for those who were overweight (OR 5.42, 95% CI: 1.57-18.68) or obese (OR 3.83, 95% CI: 1.33-11.02).

Conclusion: In summary, the study found a 40% prevalence of PreMetS among non-Hispanic Black adults, with women showing higher rates than men. Elevated blood pressure was more common in men, while abdominal obesity was significantly more prevalent in women. These findings highlight the need for effective public health strategies to prevent the onset of metabolic syndrome in both genders.

PREVALENCE OF PREMETABOLIC SYNDROME AMONG NON-HISPANIC BLACKS IN THE US

By

Oluwatomi Olufunke Amuda

Under the Direction of Ike Okosun, MS, MPH, Ph.D., FTOS, FACE

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of
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Oluwatomi Olufunke Amuda

Author's Statement

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Chapter I: Introduction

Heart disease is a significant cause of death across racial and ethnic groups in the US, as reported by the CDC. In 2021, a significant proportion (22.6%) of heart disease-related fatalities occurred among black individuals (NCHS, 2021). Furthermore, diabetes affects African Americans at a markedly higher rate than non-Hispanic white Americans, with a 77% increased risk (Chow et al., 2012). Multiple studies indicate that black Americans experience the greatest incidence of cardiovascular disease (CVD) compared to all other racial and ethnic groups in the US, contributing to reduced life expectancy and diminished overall well-being across their lifetimes (Lee, 2013). Heart disease incurred a financial burden of $229 billion in the US between 2017 and 2018, encompassing expenses related to healthcare services, prescription medications, and lost income caused to fatalities (Tsao et al., 2022).

Metabolic syndrome (MetS) is a combination of high blood sugar, high blood pressure, central obesity, low HDL cholesterol, and elevated triglycerides, is linked with an increased risk of CDV and type 2 diabetes. Research shows an increasing prevalence of MetS among adults in the US (Shin and Bohra, 2018; Hirode and Wong, 2020). Moreover, socioeconomic status has been recognized as a major factor influencing both mortality and morbidity outcomes (Shin and Bohra, 2018). These factors encompass occupation, education level, and income. Despite slight variations in the definitions of MetS among different organizations, the three most used definitions in healthcare plans and surveys are from the NCEP (National Cholesterol Education Program) ATPIII, WHO (World Health Organization), and IDF (International Diabetes Federation) (Saklayen, 2018). While these definitions have overlapping elements, their differing parameters result in variations in applicability, consistency, and positive predictive value. To address these

variations, a Joint Interim Statement (JIS) from scientific societies was established to provide a standardized definition of MetS (Alberti et al., 2009). The JIS criteria for MetS require the presence of 3 out of the following 5 abnormal conditions:

1. Central Obesity: Specific to population and country; in the USA, ≥ 88 cm for women and ≥ 102 cm for men
2. Elevated Fasting Glucose: ≥ 100 mg/dL
3. Elevated Blood Pressure: ≥ 130/85 mmHg (systolic/diastolic)
4. Dyslipidemia:

    a. High Triglycerides**:** ≥ 150 mg/dL

    b. Low High-Density Lipoprotein Cholesterol: < 50 mg/dL for women; < 40 mg/dL for men

Given that the elements of MetS are linked to a higher risk of type 2 diabetes and CVD, research has increasingly focused on premetabolic syndrome (PreMetS) as a crucial early intervention target. Koizumi et al. (2019) argue that PreMetS is the ideal stage for starting treatment to prevent the advancement to MetS and related health conditions. This study focuses on assessing the prevalence of premetabolic syndrome among non-Hispanic blacks, examining differences based on sex, age, socioeconomic status, and specific PreMetS components.

Chapter II: Literature Review

MetS comprises a group of related conditions that significantly elevate the risk of type 2 diabetes mellitus and heart disease. These conditions include central obesity, insulin resistance, hypertension, and dyslipidemia. To diagnose MetS, at least three of these metabolic abnormalities must be present, highlighting the critical importance of early detection and preventive strategies. Disturbingly, the incidence of metabolic syndrome has skyrocketed in recent decades, mirroring the global rise in obesity, affecting over 20% of Americans and Europeans (Swarup et al 2024). Patients with MetS are at a double risk for cardiovascular diseases and five times more likely to develop diabetes than those in the general population (Samson and Garber, 2014). The suggested causes of MetS include genetic factors, physical inactivity, poor dietary habits, and obesity (Xu et al., 2018). The key aspect of the syndrome is the buildup of abdominal fat, which leads to insulin resistance (Gluvic et al 2017). Insulin resistance can result from genetic predisposition or be acquired. While environmental factors are considered the primary cause of MetS and its pathogenesis, genetic factors cannot be ignored. Studies reveal that children of obese parents are at a higher risk of obesity themselves (Ferguson-Smith and Patti, 2011). Research also indicates that environmental factors during fetal development and early childhood impact disease risk and progression in later life. Therefore, maternal lifestyle and both prenatal and early postnatal nutrition are crucial in the onset and advancement of MetS (Heijmans, 2018).

Since 2011, the prevalence of MetS has steadily increased in the US (Liang et al., 2023; Hirode and Wong, 2020). By 2020, global rates showed 3% of children and 5% of adolescents with MetS (Noubiap et al., 2020). The prevalence of MetS rises with age, affecting nearly 40% of individuals in their 60s. While it affects both women and men equally, it is slightly more common in women in certain ethnic groups (Grundy, 2008).

Research has highlighted an early stage known as PreMetS, which occurs before the full onset of metabolic syndrome (Koizumi et al., 2019). While PreMetS is not officially classified as a separate disorder, it represents a condition that has not yet fulfilled the criteria for MetS. Nevertheless, PreMetS can notably increase the likelihood of advancing to MetS and act as an early warning signal for potential cardiovascular problems. Identifying PreMetS in both medical and general settings is essential for pinpointing individuals who might benefit from more thorough screening and preventive interventions. Identifying PreMetS early is essential for creating public health strategies to prevent the development of MetS and associated health problems.

Premetabolic syndrome

PreMetS is not well-defined, with various criteria used across different studies. These studies generally describe PreMetS as having a limited number of MetS components that do not fulfill the complete criteria for MetS, sometimes including a compulsory component like BMI, considering that MetS involves the presence of at least three cardiovascular risk factors (Gesteiro et al., 2021). Cho et al. (2021) described PreMetS as involving one or two MetS components, while Yin et al. (2013) and Kim et al. (2022) described it as having at least two MetS components without meeting the complete MetS criteria. Similarly, Okosun et al. (2009) defined PreMetS as the presence of two out of the required MetS components.

Reports on the prevalence of PreMetS are limited. A recent study shows a rapid increase in the proportion of American adults meeting PreMetS criteria from 1999-2000 to 2017-2020 (Amuda et al., 2024). This study highlighted variations in PreMetS prevalence by age, race, poverty, education, and BMI. In Brazil, PreMetS was found to increase with age and BMI among health

professionals (Vidigal et al., 2015). Additionally, Okosun et al. (2009) reported a high prevalence of PreMetS among the three major ethnic groups in the U.S., with the highest rates observed in women, particularly African Americans.

Component of Metabolic syndrome among adult African Americans in the US

High blood pressure

High blood pressure is identified as having a diastolic pressure of 80 mmHg or more and a systolic pressure of 130 mmHg or more. This condition heightens the risk of heart disease and other health issues. Over time, its impact has increased, making it the second highest risk factor for early mortality and disability among men and the top risk factor for women by 2016 (GBD, 2017). In the US, there is substantial documentation of racial and ethnic disparities in hypertension outcomes. While high blood pressure is a common concern across many demographic groups, it is notably more prevalent among African American men and women (Ford, 2011; Ostchega et al., 2020; Muntner et al., 2018). Among various racial groups, Black adults show the highest prevalence of hypertension at 59%. Elevated hypertension levels in African Americans result in greater cardiovascular disease (CVD) morbidity and mortality, independent of diabetes, lipid abnormalities, or obesity (Gaillard, 2018). Mozaffarian et al. (2015) demonstrated that African American women face significantly higher rates of hypertension and cardiovascular disease mortality relative to white women. Therefore, early intervention is essential for African American women to effectively manage blood pressure due to the severe cardiovascular diseases and death connected to hypertension.

Dyslipidemia

Dyslipidemia is defined as an imbalance in lipid levels, such as triglycerides, cholesterol, high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) (Mozaffarian et al., 2015). It can be triggered by diet, tobacco use, or genetic predispositions and can lead to serious cardiovascular health issues. A study revealed that the prevalence of high LDL-C was greatest among Mexican and non-Hispanic Black individuals, in comparison to non-Hispanic Whites (Pu, 2016). Low HDL-C is defined as < 50 mg/dL and 40 mg/dL in women and men respectively. Non-Hispanic blacks (20% men; 10% women) had a lower prevalence of low HDL-C compared to non-Hispanic whites (33% men; 12% women) (Pu, 2016). According to the study, Mexican Americans (34% men; 15% women) had the highest rates of low HDL-C compared to non-Hispanic whites and blacks (Pu, 2016).

Triglycerides are commonly associated with dyslipidemia and frequently occur alongside other cardiovascular risk factors, including high fasting glucose, elevated blood pressure, low HDL-C, and central obesity, Over 56.9 million US adults, more than 25%, have triglyceride levels of 150 mg/dL or higher (Fan, 2020). Evidence from numerous studies shows that Mexican Americans have the highest prevalence of the condition at 34.9% compared with blacks at 15.6% and whites at 33% (Miller, 2011; Yu, 2012). Research by Sumner et al. (2005) indicates that non-Hispanic blacks have higher HDL-C levels and lower triglyceride levels than whites. This beneficial lipid composition could theoretically shield non-Hispanic blacks from coronary heart disease, but it is still not entirely clear. The fact that African Americans with insulin resistance have higher HDL-C levels and lower triglyceride levels compared to white individuals underscores an anomalous association between lipid measures and cardiovascular disease risk (Gaillard, 2018).

Elevated fasting glucose

Diabetes is a disorder in which blood glucose (sugar) levels are elevated beyond normal ranges. Blood glucose serves as the major source of energy for the body. Insulin enables glucose to enter cells where it can be utilized for energy. In type 2 diabetes, the body struggles either with producing enough insulin or with using insulin efficiently. This situation causes excess glucose to remain in the bloodstream and prevents sufficient glucose from entering the cells. Persistent high blood glucose levels can eventually result in numerous health issues, including heart disease, vision impairment, nerve damage, and kidney disease.

Diabetes and prediabetes represent major public health epidemics in the United States, with 29.1 million adults affected by diabetes and 89 million by prediabetes (Marathe et al., 2017). These conditions present substantial public health challenges. Data from the CDC before January 2022 indicated that around 29.1 million adults in the US had diabetes, while approximately 89 million had prediabetes.

People with prediabetes or Type 2 diabetes mellitus are at a greater risk for cardiovascular problems compared to those without diabetes. Additionally, the prevalence of diabetes and its complications varies significantly across different racial and ethnic groups (Peek, 2007). Diabetes rates among African Americans and Mexican Americans are 70–80% higher than those observed in whites. In addition, they face higher death rates due to diabetes than Whites and are more heavily affected by many complications of the disease.

Central obesity

Obesity is marked by an extreme accumulation of body fat leading to health issues. According to the WHO, obesity is defined as a body mass index (BMI) >30 kg/m² (Purnell et al., 2023). In 2019, about 5 million deaths from noncommunicable diseases—including cardiovascular diseases, diabetes, neurological disorders, cancer, digestive diseases, and chronic respiratory conditions—were associated with a higher-than-optimal BMI (GBD, 2020). Obesity significantly increases the prevalence of cardiovascular diseases and diabetes. During 2017–2018, around 40% of US adults (aged 20 and older) were obese, with about 10% being severely obese (Hales et al., 2020). Compared to various racial and Hispanic groups, non-Hispanic black adults showed the highest obesity prevalence (Hales et al., 2020). The study also revealed that black women have a higher rate of obesity (56.9%) compared to black men (41.1%), consistent with other studies that report higher obesity rates among black women compared to their male counterparts.

Research indicates that waist circumference (WC) is a more dependable measure of metabolic risk than other measures, as it evaluates central fat accumulation (Ross et al., 2020; Shen et al., 2006). WC significantly influences the development of metabolic syndrome (MetS) and seems to precede other MetS components (Shen et al., 2006; Ogden, 2009). However, there is ongoing debate among different gender and racial/ethnic groups regarding whether WC is more effective for measuring metabolic risk compared to other anthropometric measures (Sumner et al., 2008). Abdominal obesity is characterized by a WC of 88 cm and 102 cm or more for women and men respectively, with differences noted across racial and ethnic groups (Alberti et al., 2009; Grundy et al., 2005).

Other risk factors of metabolic syndrome

MetS often develops due to an unhealthy lifestyle, including physical inactivity, a high-calorie, low-quality diet, smoking, and excessive alcohol consumption. Smoking is commonly identified as a key contributor to cardiovascular disease (Frati et al., 1996). Research consistently shows that smoking is associated with metabolic dysfunctions and increases the risk of MetS (Nakanishi et al., 2005; Geslain-Biquez et al., 2003). Smoking has been found to decrease insulin sensitivity, promote insulin resistance, and worsen cardiovascular risk factors (Balhara, 2012). Nakanishi et al. (2005) found that smokers who regularly smoked tobacco had 1.07 to 1.66 times higher incidences of MetS than non-smokers. Additionally, Saarni et al. (2009) studied the impact of adolescent smoking on outcomes in later life and identified smoking as a significant risk factor for both abdominal obesity and overweight.

Physical activity refers to any movement involving skeletal muscles that expends energy. Insufficient physical activity disrupts normal physiological functions, leading to outcomes such as muscle atrophy, reduced exercise capacity, insulin resistance, and energy imbalance. Physical inactivity is a known contributor to increased mortality rates (Blair et al., 1996). Studies consistently show a direct connection between physical inactivity and increased cardiovascular risk (Rennie et al., 2003; Strasser, 2013; Zhang et al., 2017). Inactivity is known to play a major role in the onset of metabolic syndrome, with insulin resistance being a critical factor linking inactivity to MetS (Roberts et al., 2013). In contrast, regular physical activity can assist in preventing and managing cardiovascular diseases, their risk factors, and other chronic health issues (Golbidi et al., 2012). In young, otherwise healthy adults, a decrease in physical activity is associated with negative metabolic outcomes, whereas an increase in physical activity correlates

with favorable metabolic effects (Olsen et al., 2008). Thus, maintaining an active lifestyle is essential for preventing the various components of MetS.

Heavy alcohol use and metabolic risk factors are primary contributors to chronic liver disease globally. Both alcohol use and metabolic syndrome are highly prevalent and often occur together, leading to a range of health issues such as chronic liver disease, hepatocellular carcinoma, and other liver-related conditions (Åberg and Färkkilä, 2020). Among the various components of MetS, diabetes and obesity have been frequently associated with liver-related outcomes in multiple studies (Stepanova et al., 2010; Jinjuvadia et al., 2013; Björkström et al., 2019). found that Reducing alcohol consumption lowers MetS risk, whereas higher alcohol intake with an increased risk (Choi et al., 2019). Additionally, a meta-analysis revealed that lowering alcohol consumption can lead to reductions in blood pressure levels (Roerecke et al., 2017).

Extensive research underscores the essential role of diet in sustaining health, as it is vital for body repair, regeneration, and providing the energy necessary for proper functioning. Modifying dietary habits—by increasing the consumption of beneficial foods and decreasing less healthy options—can greatly enhance overall wellness. In recent decades, the incidence of MetS has significantly risen, likely due to shifts in lifestyle, socioeconomic status, and dietary habits. Salas-Salvadó et al. (2016) examined the link between various dietary patterns and the likelihood of developing metabolic syndrome. The authors found that following a healthy diet lowers the prevalence of MetS, while those eating poor diets are more likely to develop it.

Chapter III: Methodology

Study design and population

Data were obtained from the National Health and Nutrition Examination Survey (NHANES). NHANES is responsible for generating health statistics for the United States. In 1999, NHANES transitioned from a one-time cross-sectional survey to a continuous program aimed at capturing a broad array of health and nutrition data to address new public health issues. Each year, it assesses a representative sample of around 5,000 individuals from 15 counties throughout the country.

NHANES gathers health data representative of the US population using a complex, multistage probability sampling technique. This information is collected via physical exams and interviews. The NHANES interview collects data on demographics, socioeconomic status, health, and dietary practices, while the examination includes a range of activities such as medical assessments, dental evaluations, physiological tests, and laboratory procedures.

This study is restricted to only non-Hispanic Blacks aged 18 and older for the year 2017 to 2020 (pre-pandemic). In March 2020, NHANES suspended field operations due to COVID-19, which left the 2019-2020 data incomplete and non-representative. To correct this, data from 2019 through March 2020 were integrated with the 2017-2018 cycle to create a thorough and representative dataset for the period from 2017 to March 2020.

To be eligible for the study, participants had to provide details on their age, race/ethnicity, waist circumference, weight, height, and both systolic (SBP) and diastolic (DBP) blood pressure, as well as undergo tests for fasting plasma glucose, triglycerides and HDL-cholesterol (HDL-C). Additional details are available in the online descriptions of variable measurements and assays

(CDC, 2023). PreMetS was defined as having two of the required number of components for MetS.

To access sociodemographic differences in the prevalence of PreMetS in non-Hispanic blacks, characteristics such as age, education, BMI, and Family income to poverty (FIR) were analyzed. Age was categorized into 3 groups: 18-39, 40-59, and 60 and over. Education was categorized into two levels: high school graduate or less, and college or higher. BMI was determined by dividing weight in kilograms by the square of height in meters (kg/m^2). The resulting values were classified into three categories based on the WHO definition (WHO, 2006): underweight and normal (<25), Overweight (25 and 29), and obesity (>30). FIR was used to evaluate poverty, determined by dividing the total family income by the established poverty threshold values.

In this study, FIR was used to classify individuals as below the poverty line if <1.3 and above the poverty line if >1.3. Behavioral factors such as alcohol misuse and smoking were also assessed for association with PreMetS. Alcohol misuse was defined as consuming more than 4 or 5 drinks daily while smoking as having consumed more than 100 cigarettes over a lifetime. (Pomerleau et al., 2004; CDC, 2018).

Statistical analysis

Data analyses were performed using the SPSS version 29.0.10 (171). The analyses were stratified by sex to estimate the prevalence of PreMetS nd its individual components. The Chi-squared (χ^2) test was used to determine statistical significance. Logistic regression analyzed the association between PreMetS and variables such as age category, education level, BMI, and FIR, reporting

odds ratios (OR) and 95% confidence intervals (CI). Statistical significance was determined using p-values below 0.05 or by examining the 95% confidence intervals.

Chapter IV: Results

From 2017 to 2020, there were 4,098 participants representing the non-Hispanic black population (Table 1). Among these participants, 49.4% were male and 50.6% were female. The participants had an average age of 33.6 years, a BMI of 26.6 kg/m², and a FIR of 1.9 throughout the study. Out of the total participants, only 171 met the criteria for analysis, with 48% being male and 58% being female (Table 2). The overall prevalence of PreMetS was 40.4%, with a higher prevalence among females (58%) compared to males (42%) (Figure 1).

For adults aged 40-59 and those aged 60 and above, the prevalence of PreMetS was 35.9%, slightly higher than the 28.1% observed in adults aged 18-39 years (Figure 2). The prevalence of individual risk factors of pre-metabolic syndrome (PreMetS) shows notable differences between men and women, as illustrated in Table 3. The data indicates significant prevalence rates for elevated triglycerides (27.6% in men and 17.5% in women), elevated blood glucose (48.3% in men and 55% in women), low HDL cholesterol (69% in men and 45% in women), and abdominal obesity (27.6% in men and 62.5% in women). Men exhibited a higher prevalence of elevated triglycerides, blood glucose, and blood pressure than women. Conversely, women had a higher prevalence of abdominal obesity and low HDL cholesterol. Among males, all individual risk factors of PreMetS except abdominal obesity were significant, whereas, among females, all risk factors except elevated blood pressure were significant.

To examine the relationship between behavioral and sociodemographic factors (age, education, BMI, and family poverty-income ratio) and the likelihood of PreMetS, focusing on sex-specific differences, logistic regression analysis was utilized as detailed in Table 4. BMI was significantly

associated with higher odds of PreMetS in females. Overweight females had an OR of 5.42 (95% CI: 1.57-18.68), and obese females had an OR of 3.83 (95% CI: 1.33-11.02), indicating increased odds of PreMetS. For males, there was an increase in odds of PreMetS for both overweight (OR: 1.78, 95% CI: 0.56-5.68) and obese (OR: 1.20, 95% CI: 0.36-4.03) categories, although these were not significant. Males aged 40-59 showed higher odds of PreMetS (OR: 2.60, 95% CI: 0.71-9.59) compared to females (OR: 1.39, 95% CI: 0.46-4.16). For individuals aged 60 and above, females had higher odds of PreMetS (OR: 1.49, 95% CI: 0.53-4.21) compared to males (OR: 1.30, 95% CI: 0.35-4.80). Educational attainment did not increase the odds of PreMetS in both males and females. Smoking did not increase the likelihood of PreMetS for either men or women, whereas alcohol misuse did elevate the likelihood of PreMetS in both genders (Men: OR 1.56, 95% CI 0.281-8.6); Women: OR 5.41, 95% CI 1.01-28.79. The family income-to-poverty ratio slightly increased the odds of PreMetS in men (OR: 1.26, 95% CI: 0.43-3.71) compared to women (OR: 1.06, 95% CI: 0.41-2.71).

Sex-specific multivariate analysis was conducted to evaluate the relationship between behavioral and sociodemographic factors and PreMetS (Table 5). Age was found to increase the likelihood of PreMetS in men (OR: 1.63, 95% CI: 0.13-20.02; OR: 1.25, 95% CI: 0.10-16.07) but not in women (OR: 0.13, 95% CI: 0.04-4.17; OR: 0.09, 95% CI: 0.03-3.20) while controlling for BMI, education, smoking, alcohol misuse, and FIR. BMI increased the odds of PreMetS in both males and females. Educational level increased the likelihood of PreMetS in men (OR: 1.82, 95% CI: 0.28-11.85) and not in women (OR: 0.03, 95% CI: 0.01-0.94). Smoking and alcohol misuse did not increase the odds of PreMetS in either gender, while FIR increased the odds of PreMetS in women (OR: 6.69, 95% CI: 0.30-148.22) but not in men (OR: 0.89, 95% CI: 0.10-7.91).

Table 1: Baseline characteristics of non-Hispanic blacks, NHANES 2017-2020

Sample size: 4098

Characteristics		**N**
Gender (%)		**4098**
Male	49.4	2024
Female	50.6	2074
Education (%)		**2455**
High school graduate or less	44.3	1087
College or higher	55.7	1368
Age Cat (%)		**2555**
18-39	32.6	472
40-59	31.9	814
60 and over	35.6	909
Smoking (%)		2521
Yes	40.7	
No	59.3	
Alcohol Misuse (%)		1**984**
Yes	15.4	
No	84.6	
Age (years)	33.6 ± 24.6	**4098**
BMI (kg/m2)	26.6 ± 8.5	**3448**
Family poverty- to- income ratio	1.9 ± 1.5	**3435**

Diastolic BP (mmHg)	71.2 ± 11.8	**2676**
Systolic BP (mmHg)	119.1 ± 19.0	**2676**
Triglycerides (mg/ dl)	101.1 ± 65.5	**1228**
Blood Glucose (mg/ dl)	110.5 ± 39.7	**1203**
HDL-cholesterol (mg/dl)	53.4 ± 15.3	**2841**
Waist Circumference (cm)	89.7 ± 23.1	**3303**

Mean ± SD; Age Cat (Age category)

Table 2: Baseline characteristics of study participants with premetabolic syndrome

Sample size:171

Characteristics	**PreMetS**	**N**	**No PreMetS**	**N**
Sex (%)		**69**		**102**
Male	42.0	29	52	53
Female	58.0	40	48	49
Education (%)		**64**		**82**
High school graduate or less	42.2	13	37.8	13
College or higher	57.8	14	62.2	18
Age Cat (%)		**64**		**85**
18-39	28.1	11	36.5	31
40-59	35.9	23	27.1	23
60 and over	35.9	23	36.5	31
Smoking (%)		**64**		**79**
Yes	40.6	26	44.3	35
No	59.4	38	55.7	44
Alcohol Misuse (%)		**39**		**59**
Yes	10.3	4	25.4	15
No	89.7	35	74.6	44
Age (years)	47.3± 19.2	**69**	42.9±31.0	**102**
BMI (kg/m2)	26.8 ± 8.9	**69**	24.1±7.5	**102**
Poverty- to- income ratio	2.3± 1.5	**59**	2.2±1.6	**84**

Diastolic BP (mmHg)	71.4 ± 11.2	**69**	68.8±9.5	**102**
Systolic BP (mmHg)	118.7± 17.7	**69**	115.6±15.1	**102**
Triglycerides (mg/ dl)	110.6 ± 70.5	**69**	87.0±42.0	**102**
Blood Glucose (mg/ dl)	108.3 ± 18.5	**69**	100.2±20.8	**102**
HDL-cholesterol (mg/dl)	52.1± 16.6	**69**	57.6± 13.3	**102**
Waist Circumference (cm)	89.7 ± 24.5	**69**	81.0±22.2	**102**

Mean ± SD; Age Cat (Age category) No PreMetS(Normal)

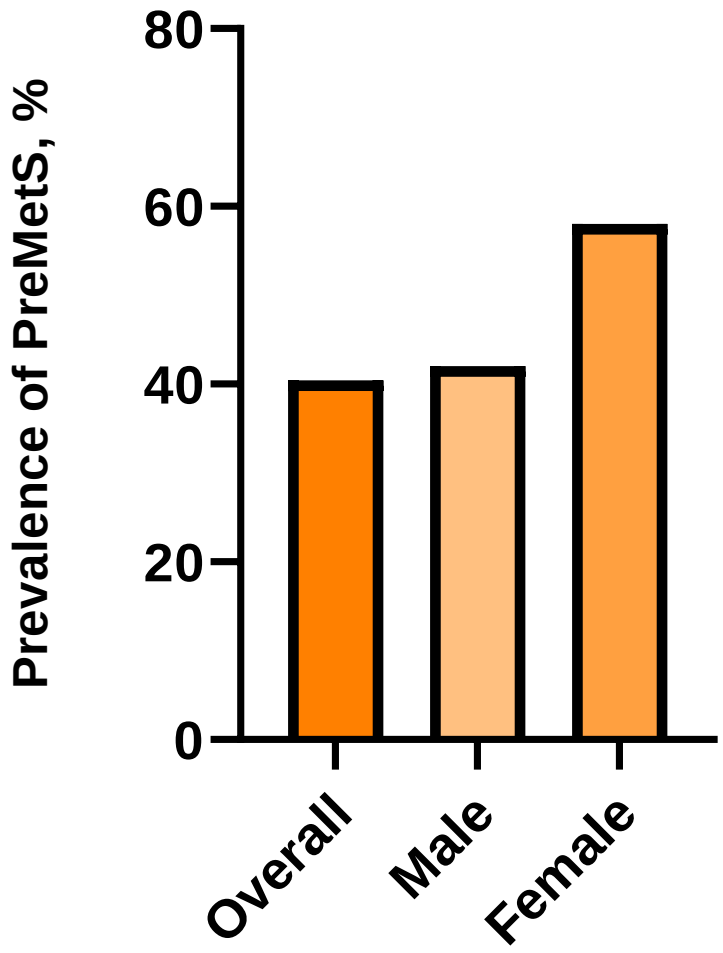

Figure 1: Prevalence of PreMetS among study participants

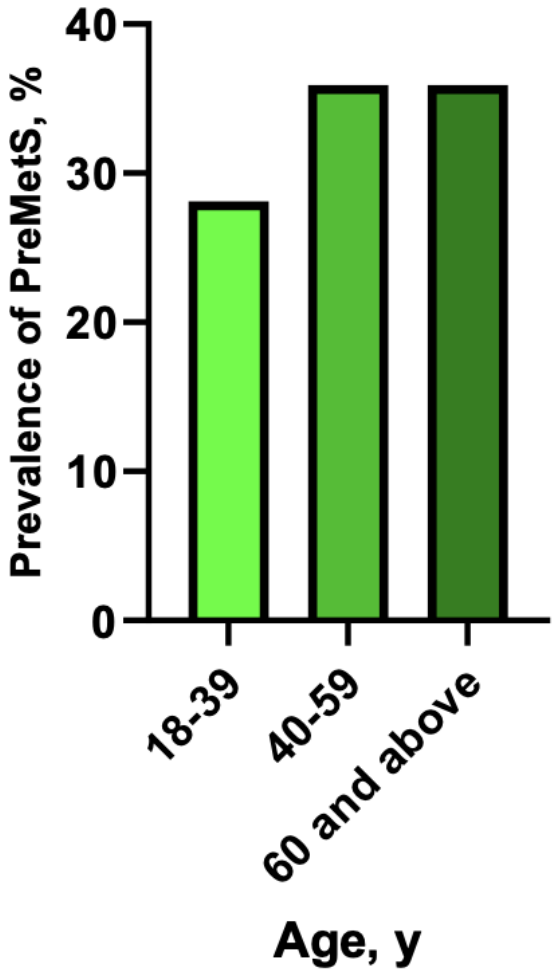

Figure 2: Prevalence of PreMetS among study participants stratified by age

Table 3: Prevalence of individual premetabolic syndrome risk factors among US Adults by Sex

	Male			**Female**		
Characteristics	**PreMetS (N=29)**	**No PreMetS (N=53)**	**p-value**	**PreMetS (N=40)**	**No PreMetS (N=49)**	**p-value**
Elevated Triglycerides (%)	27.6	7.5	**.014***	17.5	4.1	**.037***
Elevated Blood Pressure (%)	48.3	15.1	**.001***	20.0	12.2	**.318**
Elevated Blood Glucose (%)	69.0	34.0	**.002***	55.0	20.4	**<.001***
Low HDL Cholesterol (%)	27.6	3.8	**.002***	45.0	20.4	**.013***
Abdominal obesity (%)	27.6	15.1	**.172**	62.5	24.5	**<.001***

* Significant; p-value 0.05 No PreMetS(Normal)

Table 4: Univariate analysis of the association between selected independent characteristics and premetabolic syndrome by sex

	Male	**Female**
Characteristics	**OR (95% CI)**	**OR (95% CI)**
Age Category		
18-39	1	1
40-59	2.60 (0.71-9.59)	1.39(0.46-4.16)
60 and over	1.30 (0.35-4.80)	1.49 (0.53-4.21)
BMI Category		
Underweight and Normal	1	1
Overweight	1.78 (0.56-5.68)	5.42(1.57-18.68)
Obesity	1.20(0.36-4.03)	3.83(1.33-11.02)
Education		
High school graduate or less	1	1
College or higher	1.01(0.38-2.70)	0.63(0.25-1.62)
Smoking		
No	1	1
Yes	0.87(0.33-2.29)	0.86(0.35-2.22)
Alcohol Misuse		
No	1	1
Yes	1.56(0.281-8.6)	5.41(1.01-28.79)
Family poverty- to- income ratio		

<1.3	1	1
1.3 +	1.26 (0.43-3.71)	1.06(0.41-2.71)

Table 5: Multivariate analysis of the association between selected independent characteristics and premetabolic syndrome by sex

	Male	**Female**
Characteristics	**OR (95% CI)**	**OR (95% CI)**
Age Category		
18-39	1	1
40-59	1.63(0.13-20.02)	0.13(0.04-4.17)
60 and over	1.25 (0.10-16.07)	0.09 (0.03-3.20)
BMI Category		
Underweight and Normal	1	1
Overweight	6.12(0.71-52.83)	4.45(0.13-159.23)
Obesity	4.50(0.32-62.38)	5.58(0.23-135.54)
Education		
High school graduate or less	1	1
College or higher	1.82(0.28-11.85)	0.03(0.01-0.94)
Smoking		
No	1	1
Yes	0.56(0.07-4.59)	0.10(0.06-1.87)
Alcohol Misuse		
No	1	1
Yes	1.05(0.07-15.95)	0.10(0.03-3.92)

Family poverty- to- income ratio		
<1.3	1	1
1.3 +	0.89 (0.10-7.91)	6.69(0.30-148.22)

Chapter V: Discussion

In the United States, CVD ranks as the top cause of death, especially prevalent among individuals of African descent (Clark and El-Atat, 2007). MetS is linked to developing both type 2 diabetes and CVD. However, there is increasing focus on the pre-disease stage, before the onset of MetS, as an effective treatment window (Chen et al., 2021). Therefore, addressing PreMetS may be optimal for early intervention, potentially preventing progression to MetS or serving as a crucial phase in disease development (Koizumi et al., 2019). Identifying the prevalence and specific components of PreMetS in non-Hispanic populations can guide targeted public health initiatives for this community.

This study found that approximately 40% of non-Hispanic adults in the US had PreMetS, with a higher prevalence among females (58%) compared to males (42%). It was also observed that individual components of PreMetS, such as elevated triglycerides, elevated blood glucose, and low HDL cholesterol, were prevalent among both men and women. Elevated blood pressure was notably significant in men, while abdominal obesity was particularly significant in women. Men exhibited higher rates of elevated triglycerides, blood glucose, and blood pressure, whereas women showed a greater prevalence of abdominal obesity and low HDL cholesterol. This observation aligns with the findings of Lee et al. (2018). The higher prevalence of high blood pressure among men aligns with several studies indicating a greater incidence of hypertension among African Americans (Nwankwo et al., 2013; Yoon et al., 2015; Ostchega et al., 2020; Aggarwal et al., 2021). These elevated hypertension rates are known to contribute to increased CVD morbidity and mortality in this population (Yoon et al., 2015). In this study, a higher prevalence of high blood pressure was seen in men compared to women, which contrasts with Aggarwal et al. (2021), who

found that black women had a higher prevalence of high blood pressure compared to men. However, Ostchega et al. (2020) showed a slightly higher prevalence in black men (57.2%) than in women (56.2%).

Ross et al. (2020) argue that BMI alone is inadequate for accurately assessing or managing the cardiometabolic risks associated with increased body fat in adults. Waist circumference offers a straightforward and clinically applicable method for evaluating abdominal adiposity. In this study, the prevalence of abdominal obesity among women was 62.5% (p-value < .001), which aligns with findings from Moore et al. (2017) that reported a higher prevalence of abdominal obesity among Black women compared to men. Additionally, BMI was found to significantly increase the likelihood of PreMetS in women more than in men. This study also found that education level did not affect the odds of PreMetS in men, but for women, having a high school diploma or equivalent increased the likelihood of PreMetS. While age was associated with a higher risk of PreMetS in men, it did not significantly affect PreMetS risk in women. The family poverty-to-income ratio was found to slightly increase the odds of PreMetS for both genders

The notable prevalence of abdominal obesity in women, hypertension in men, and the significant correlation of overweight in women underscore specific areas that need targeted intervention. Addressing these key risk factors through behavioral and lifestyle changes is crucial for reducing the overall burden of Metabolic Syndrome (MetS) within this population. Implementing modifications such as dietary changes, increased physical activity, effective weight management, and stress reduction can significantly help in the prevention and management of abdominal obesity, hypertension, and overweight. These efforts, in turn, can help reduce the rising incidence

of MetS among non-Hispanic Blacks. (Charchar, et al, 2024; Scisney-Matlock et al 2009; Lemacks et al., 2013; Kumanyika et al., 2014).

Diet is crucial in the prevention and management of MetS. It is essential to maintain a balanced diet that incorporates vegetables, fruits, lean proteins, and whole grains and reduces the intake of sodium and processed foods. Agodi et al. (2018) highlighted that dietary habits greatly affect MetS prevalence. Their findings indicated that consuming a diet abundant in fish, vegetables, fruits, and cereals correlates with a healthier metabolic profile and a reduced risk of MetS. Furthermore, dietary programs aimed at lowering salt intake have been shown to enhance blood pressure control (Abrahamowicz et al., 2023). Promoting healthier eating habits through nutritional interventions can result in substantial improvements in weight management and overall metabolic health. Participating in consistent physical activity, including both aerobic and strength training exercises, is vital for lowering the risk factors associated with MetS. Research by Newton et al. (2013) demonstrated that physical activity significantly decreases the likelihood of MetS among African American adults. Similarly, Amin et al. (2023) found that aerobic exercise, in particular, can reduce waist circumference, thereby improving MetS. Implementing community programs that promote consistent exercise can result in substantial health benefits and lower the prevalence of MetS.

Implementing effective weight management strategies is crucial for addressing MetS. The combined approach of physical activity and dietary adjustments has been proven to combat MetS (Kirkendoll et al., 2010). These strategies often encompass behavioral therapy, support groups, and tailored weight loss plans. Achieving sustainable weight loss not only reduces abdominal obesity but also decreases the risk of hypertension and related conditions. A lifestyle intervention

was shown to lower the prevalence of MetS in overweight black women, significantly improving waist circumference, blood pressure, and triglyceride levels (Mamun et al., 2020). Stress has been linked to the severity of MetS among African Americans (Cardel et al., 2018). Therefore, managing stress is a vital aspect of addressing MetS. Studies have demonstrated that engaging in mindfulness, yoga, and ensuring adequate sleep can significantly lower stress levels (Leonidis et al., 2021). Integrating these practices into everyday routines can yield significant benefits and improve overall well-being. Reducing stress can positively affect hypertension, thereby improving overall metabolic health (Kalinowski, 2021).

One of the strengths of this study is its ability to report the prevalence of PreMetS among non-Hispanic Black adults and to highlight sex-specific differences in the prevalence of individual risk factors, which can inform more targeted public health interventions. A key limitation of this study is its restricted sample size, as it examines only one racial group within a specific timeframe of the NAHNES dataset. Additionally, the lack of a precise definition of PreMetS is noteworthy. Different studies propose various criteria for identifying PreMetS; in this study, PreMetS was defined as meeting two of the components required for MetS (Okosun et al., 2009; Yen et al., 2013; Kim et al., 2021). A standardized definition would enhance the comparability of PreMetS prevalence across studies. While this study analyzed the prevalence of individual PreMetS risk factors, examining their co-occurrence could elucidate common determinants of PreMetS in both genders. Moreover, analyzing PreMetS trends can aid in identifying patterns crucial for public health planning.

Conclusion

In the US, the prevalence of PreMetS among non-Hispanic black adults was 40%, with women exhibiting a higher prevalence than men. Elevated blood pressure was notably more common in men, while abdominal obesity was significantly more prevalent among women. Furthermore, BMI was found to increase the risk of PreMetS for both genders, with a more significant impact on women. Analyzing the patterns and connections among these risk factors will support the creation of improved public health approaches to reduce the risk of metabolic syndrome in both genders.

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