Cardiovascular Health of North Carolina Undergraduates

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BACKGROUND Cardiovascular disease is highly prevalent in Eastern North Carolina (ENC). In this study, we investigated cardiometabolic risk in young adults of ENC by sampling entrant undergraduates at East Carolina University (ECU).

METHODS From June to October of 2010, 525 undergraduates were screened for elevated body mass index (BMI), blood pressure, lipids, blood glucose, inactivity, smoking, history of diabetes or hypertension, and family history of coronary disease. Participants were classified as high-risk if they had 3 or more cardiovascular risk factors or as “MetS” if they satisfied the criteria for metabolic syndrome.

RESULTS Forty-four percent of those screened had 2 or more risk factors, 12.5% had 3 or more risk factors, and 1.3% met criteria for MetS. Low levels of high-density lipoprotein (27.6%), overweight status (27.2%), and inactivity (27.1%) were leading risks. Females had an increased risk of inactivity compared to males (relative risk [RR] = 1.8; 95% CI, 1.3-2.52). Blacks had a 4-fold higher risk of metabolic syndrome (RR = 4.21; 95% CI, 1.0-18.4), and black females had a high risk for obesity (RR = 5.7; 95% CI, 2.5-13) and systolic blood pressure elevation (RR = 4.8; 95% CI, 1.5-15). Students recognized cardiovascular disease as a valid risk to their well-being.

CONCLUSION ECU undergraduates have a high prevalence of multiple cardiovascular risk factors. High-risk and MetS students recognize cardiovascular disease as a significant health risk, but they mistakenly maintain the self-perception that they are healthy. Efforts to understand risk perception and personal strategies of risk application are needed for this population of young adults.

The rising prevalence of hypertension and metabolic syndrome among adolescents and young adults over the past few decades has been well documented [1-10]. North Carolina has begun to make strides in the campaign against early obesity and cardiovascular risk by participating in a 7-year plan called Eat Smart, Move More North Carolina [11], which engages local businesses, schools, and other community agencies in a partnership to improve awareness of nutrition and opportunities for healthy eating and physical activity.

Heart Healthy is a program initiative to study cardiovascular risk factors and risk awareness among college students at East Carolina University (ECU). College students represent a unique cohort of young adults who can be captured through existing university forums for cardiovascular screening and follow-up. All ECU undergraduate students are required to take 3 credits of health-related courses including Health 1000. Part of the class requirement involves attending a number of extracurricular “passport events” designed to stimulate practical interest and knowledge in undergraduate health; we planned a specific Health 1000 passport event for cardiovascular screening. We also utilized student involvement fairs during summer undergraduate orientation to capture entrant undergraduates for screening and delivery of focused cardiovascular health education.

Methods

In order to maximally capture the cohort of interest despite having limited resources, we used nontraditional health delivery settings to conduct cardiovascular risk screening and education. Screening events were conducted at 2 separate locations: the student recreation center and the student dining hall. Free Heart Healthy t-shirts and discount cards offering local, healthy food options were provided to participants as incentives to complete screening.

Testing involved a 10-question health survey, measurement of weight and blood pressure (BP), and an onsite finger-stick blood test that measured cholesterol and random blood glucose (BG). Participants with abnormal BP, body mass index (BMI), BG, or lipid levels were advised to follow up with the student health clinic or with their personal physician for further assessment. High-risk participants received an e-mail follow-up detailing their individual screening risk results and recommendations for further evaluation.

The internally validated health survey gathered self-reported information regarding family history of cardiovascular disease and lifestyle-related cardiovascular risks such as smoking and level of physical activity. Students were asked about their health risks and perceptions of individual wellness. Weight was measured using a digital scale with shoes removed. BMI was calculated based on self-reported height and measured weight. Single, standing BP measurements were taken manually using an aneroid cuff on the upper extremity after 2-5 minutes of rest. Whole blood analysis of nonfasting BG, total cholesterol (TC), high-density...
Lipoproteins (HDL), and triglyceride (TG) was conducted onsite using the Cholestech LDX Analyzer. Low-density lipoprotein (LDL) values were calculated using the Friedewald equation [12]. BG or lipid values that exceeded Cholestech test limits were set to one digit above the maximum value or below the minimum value for analysis.

Cardiovascular risk factors were defined as the presence of first-degree family history of coronary disease or coronary equivalent, elevated systolic BP at or above 140 mmHg, diastolic BP at or above 90 mmHg, glycemic risk defined as random BG above 140 mg/dL, presence of any lipid risk factor, inactivity, and positive smoking status. We accepted first-degree family history of coronary disease at any age, as most of the participants were not able to identify ages of onset for these familial risks. Inactivity was defined as fewer than 20 minutes of physical activity 3 times a week, which is slightly below the American Heart Association minimum recommendation for adults of 150 minutes per week of moderate intensity exercise or 75 minutes per week of high intensity exercise [13]. Smoking was defined as any current cigarette smoking.

Lipid risks were defined as TC greater than 240 mg/dL, HDL less than 50 mg/dL for females and less than 40 mg/dL for males, LDL greater than 160 mg/dL, or TG greater than 350 mg/dL. The National Cholesterol Education Program - Adult Treatment Panel (NCEP-ATPIII) [13] utilized an HDL cutoff of less than 40 mg/dL as the risk level for adult males and females. However, for a younger population in whom the goal is early detection of risk, we elected to adopt the stricter criteria of HDL less than 50 mg/dL in females and less than 40 mg/dL in males. Participants were classified as high-risk if they had 3 or more risk factors and were classified as “MetS” if they met 3 or more of the following specific metabolic criteria: obese (BMI ≥ 30), elevated systolic or diastolic BP, elevated nonfasting BG, or presence of any lipid risk factor.

Descriptive analysis was performed by the ECU Statistics Department utilizing Excel and R statistical programming modules. Fisher’s exact test was used for analysis of risk profile and to detect differences in continuous variables between each demographic group. BMI, lipid, and BP distribution were examined by highest and lowest quartiles of activity using Welch 2-sample t-test.

This study was approved by ECU’s institutional review board as an expedited study for the use of human subjects in research. Written consent was obtained onsite from all participants.

Results

Between June and October of 2010, a total of 525 undergraduate students—12% of the entrant class—were screened for cardiovascular risk factors. A total of 425 students were screened over 8 student involvement fairs in the student recreation center. A subsequent 100 students were screened in the atrium of the student dining hall as part of a Health 1000 passport event. Demographic characteristics of study participants reflected the overall composition of this ECU class [14], with a mean age of 18.2 ± 1.32 years, 60.7% female, and 78.1% white (see Figure 1). Students of mixed or other racial backgrounds accounted for less than 8% of participants. Complete biometric data were available for 486 of 525 participants (see Table 1 for subanalyses by race and sex). Pre-existing cardiovascular disease, other than a history of heart murmur or mitral valve prolapse, was not reported in this cohort. Reported prevalences of diabetes (1.3%) and hypertension (2.7%) were similarly low. Reported first-degree family history of coronary disease or equivalent was 8.8%.

The most common individual risk factors were a BMI of at least 25 (27.6%), low levels of HDL (27.6%), and a sedentary lifestyle (27%; see Figure 2). Just over 40% of participants had 2 or more risk factors, and 11.7% were high-risk with 3 or more cardiovascular risk factors. High-risk participants were present among black females at a frequency of 18.2%, among white males at a frequency of 12.7%, among black males at a frequency of 10.3%, and among white females at a frequency of 9.5%. No significant association was found between high-risk profile and sex or race.

The average BMI of this cohort was 23.8. Seven percent of students were either obese (BMI ≥ 30; 4.8%) or morbidly obese (BMI > 35; 2.5%) and a further 21% were overweight (BMI ≥ 25). Black students were significantly more likely than white counterparts (RR = 3.03; 95% CI, 1.09–8.39; P = .03) to have BP elevation (RR = 3.93; 95% CI, 2.08–7.43), with black females most likely to be obese (RR = 5.73; 95% CI, 2.53–12.95) and black males most likely to be overweight (RR = 1.78; 95% CI, 1.16–2.72; see Table 2). White females were the least likely to be obese, with a mean BMI of 23, compared to 27.2 for black females (see Table 1). Although no parameters reached significance when compared by upper and lower quartiles of BMI, differences were detected in BP and HDL level when comparing lean (BMI < 25) participants to obese and overweight (BMI ≥ 25) participants. Obese and overweight participants were prone to have BP elevation (RR = 3.93; 95% CI, 2.37–6.51) and HDL risk (RR = 1.7; 95% CI, 1.3–2.2).

BP readings in the hypertensive range were detected in 10.5% of participants; 7.8% of participants had systolic elevation and 5.5% had diastolic elevation. White males had higher risk of systolic BP elevation compared to their female counterparts (RR = 5.58; 95% CI, 2.3–13.5). Black males had higher frequency of diastolic BP elevation compared to their white counterparts (RR = 3.03; 95% CI, 1.09–8.39; P = .03). A BMI above 25 was a strong predictor for hypertensive risk (RR = 3.9; 95% CI, 2.4–6.5).

Glycemic risk was detected in 8.6% of participants. White males had an average BG level that was 10-14 mg/dL higher than that of other participants; however, there was no significant risk predominance based on a random BG cutoff of 140 mg/dL (see Tables 1 and 2). Low HDL was detected 3 times more often in black females than in black males.
(35% versus 10.3%; RR = 3.1; 95%, CI 1.0–9.8); there was no difference between males and females among white students. Aside from low HDL, lipid risk factors were infrequent; few participants (1.3%) had more than a single lipid abnormality.

Twenty-seven percent of participants were sedentary, and 51% engaged in moderate activity at a frequency between 20 minutes 3 days per week and 20 minutes daily. Twenty percent of participants reported engaging in more than 1 hour of exercise daily or participating in athletics. Females were 86% more likely to be sedentary (RR = 1.9; 95%, CI 1.3–2.5), with black females having the highest likelihood of inactivity (RR = 1.43; 95% CI, 0.97–2.11 versus white women). Conversely, highly active students—those exercising more than 1 hour per day or reporting athletic participation—were more likely to be male (RR = 1.7; 95% CI, 1.7–3.2). Sedentary students actually had a trend towards lower mean systolic BP (110 mmHg versus 115.7 mmHg; P = .04) but did not differ from active students in terms of mean diastolic BP, BMI, BG level, or lipid measurements.

Seven participants (1.3%) had metabolic syndrome (see Figure 1). Black race was associated with metabolic syndrome (RR = 4.2; 95%, CI 1.0–18.4). Amongst MetS and high-risk participants, 85% felt that their overall health was equivalent to or better than that of their peers. Only 13–14% rated their health as poor. In comparison, 59% of participants with 2 or fewer cardiovascular risk factors ranked their health as equivalent to or better than that of their peers. MetS participants identified cardiovascular disease as their primary health risk factor (57%), ahead of accidents (29%), violence (14.2%), and cancer (14.2%). High-risk participants ranked cardiovascular health second, while participants with 2 or fewer risk factors rated cardiovascular health third behind accidents and cancer.

**Discussion**

The National Health and Nutrition Examination Survey (NHANES) of young adults aged 18–29 years [15] examined rates of obesity, hypertension, diabetes, dyslipidemia, and metabolic syndrome across the United States. NHANES data were stratified to compare normal-weight individuals (BMI < 25) to severely obese individuals (BMI > 40). The NHANES study reported higher rates of obesity (26.2%) and metabolic syndrome (3.5–14.9%) than those found in the ECU cohort, which had rates of obesity and inactivity more comparable to studies of older adolescents performed over the past 2 decades [1, 5–8].

The prevalence of hypertensive BP measurements in our study (10.5%) overlapped with the rates of hypertension in NHANES (4.7–19.8%), yet our value remained fairly low compared to the combined hypertensive and prehypertensive risk found in studies of older adolescents (20–23%)—numbers which are nearly reflective of the prevalence of adult hypertension in ENC (28.8%) [2–5, 11]. As in NHANES...
and older adolescent studies, elevated BMI in this study strongly correlated with increased risk of hypertensive BP measurement. The ECU cohort had a relatively high prevalence of established diabetes and newly detected glycemic risk; however, it is difficult to compare these rates to those of established cohorts due to differences in measurement techniques and definitions of glycemic risk.

Amongst high-risk and MetS students, we identified a relative discrepancy between perceived and actual health status that may represent a barrier to successful cardiovascular risk modification in young adults. Despite the fact that high-risk adolescents and young adults have been demonstrated to have early changes in vascular and cardiovascular pathophysiology presaging the onset of accelerated atherosclerosis, this study highlights the need for targeted interventions to improve health outcomes in this population.

### TABLE 1.
Biometric Risk Measurements

| Risk measurement                  | Heart Healthy participants (n = 525) | White males (n = 158) | Black males (n = 29) | White females (n = 252) | Black females (n = 44) |
|-----------------------------------|-------------------------------------|-----------------------|---------------------|-------------------------|------------------------|
| Body Mass Index                   | 23.8 ± 4.3                          | 23.9 ± 3.7            | 25.0 ± 4.4          | 23.0 ± 3.5*             | 27.2 ± 7.9*            |
| Systolic blood pressure           | 116.9 ± 14.2                        | 123.8 ± 12            | 131.3 ± 17.9        | 112.5 ± 11.7            | 115.0 ± 16.1           |
| Diastolic blood pressure          | 72.4 ± 10.5                         | 74.4 ± 9.5            | 77.0 ± 10.2         | 70.8 ± 10.2             | 72.3 ± 13.7            |
| Blood glucose                     | 109.3 ± 23.3                        | 115.9 ± 23.4          | 104.3 ± 20.3        | 106.0 ± 20.0            | 101.3 ± 16.7           |
| Total cholesterol                 | 157.8 ± 30.9                        | 148.8 ± 27.2*         | 161.8 ± 30.8        | 162.6 ± 32.4            | 160.8 ± 34.2           |
| Triglyceride                      | 109.4 ± 64.5                        | 123.2 ± 81.1          | 119.5 ± 68.0        | 99.7 ± 47.0*            | 81.3 ± 32.0*           |
| Low-density lipoprotein           | 87.4 ± 25.7                         | 88.1 ± 23.4           | 86.9 ± 23.2         | 90.6 ± 26.8             | 95.3 ± 30.4            |
| High-density lipoprotein          | 50.9 ± 12.9                         | 50.8 ± 13.3           | 52.9 ± 11.9         | 45.7 ± 10.3*            | 54.2 ± 12.4            |

Note. Asterisks denote significant differences between demographic groups. In the upper portion of the table, the total of males and females is less than 525 because 1 participant did not report his or her sex. Similarly, the total of white participants and black participants is less than 525 because Hispanic and Asian participants were excluded from this table.

**FIGURE 2.**
Individual Cardiovascular Risk Prevalence

![Figure 2](image_url)

Note. BMI, Body Mass Index; DBP, diastolic blood pressure; SBP, systolic blood pressure.

Family history (FH) was positive if there was history of coronary disease or disease equivalent in any first-degree family member of any age. Diabetes mellitus (DM) was positive if there was a pre-existing diagnosis of diabetes. Hypertension (HTN) was positive if there was a pre-existing diagnosis of hypertension. Smokers were those who engaged in any current cigarette smoking. Sedentary individuals were those who engaged in less than 20 minutes of any intensity exercise 3 times a week. Blood glucose (BG) was positive if nonfasting BG level was above 140 mg/dL. Any lipid risk was positive if any one of the following was met: total cholesterol > 240 mg/dL; high-density lipoprotein < 40 mg/dL in a male or < 50 mg/dL in a female; low-density lipoprotein > 160 mg/dL; or triglyceride > 350 mg/dL.
cardiovascular disease and potential early mortality [16–21], it remains difficult to motivate these persons to make significant lifestyle modifications. Individuals at this stage usually remain asymptomatic, although they may already have reversible organ dysfunction such as reduced vascular reactivity, ventricular stiffening and hypertrophy, carotid intima medial thickening, coronary artery calcification, and advanced coronary artery atherosclerotic plaques [22–28]. Effective motivation often remains lacking, even after these individuals have been educated regarding their cardiovascular risk. For example, MetS participants correctly ranked cardiovascular health as their primary risk factor 57% of the time, compared to 19.3% of high-risk participants and 8.7% of the general cohort. Despite this fairly accurate recognition of individual cardiovascular risk, there was still a discrepancy in health perception, with only 15% of high-risk and MetS participants rating their health status as worse than that of their peers—just 10% higher than low-risk individuals with 2 or fewer cardiovascular risk factors.

Late adolescence and early adulthood represent a critical transition period for consolidating lifestyles and dietary habits. Underutilization of traditional health services and resources [29–30] may occur for a number of reasons, including lower priority given to health-related issues relative to work, academic, and peer-related issues or lack of understanding of how to correctly utilize health resources. Other factors may include denial of health risks, desire to avoid connotation of ill health, lack of financial resources, lack of affordable health insurance options, and inconvenience.

Surprisingly, students in this study who reported a highly active lifestyle or participation in athletics showed a non-significant trend towards a higher number of cardiovascular risk factors such as elevated BG, BMI, and abnormal lipids. This could be a result of sampling bias or the effect of other high-risk behaviors associated with peer status, body image, and athletic training. Among athletes and highly motivated students, factors that may come into play include excessive use of energy or electrolyte replacement drinks; increased caffeine and fast food intake; or use of steroids, other muscle building supplements, or weight loss supplements. Since a large majority of active students were male, another possibility is that male participants over-report their activity level relative to females, or that male sex conveys an underlying risk that overrides the benefits of an active lifestyle.

The ECU cohort was comprised mostly of young adults 16–23 years of age, which represents only 21.5% of the ENC population. Results from this study may not be applied to young adults generally. Limitations of this study include the cross-sectional, single institution design and the low representation of blacks (in view of the fact that blacks comprise 28.8% of the wider ENC population) [31]. This low percentage was, however, reflective of the lower numbers of blacks (17.7%) within the ECU undergraduate cohort (see Figure 1). An additional limitation is that the voluntary nature of screening may have introduced sample bias towards students who already had an interest in cardiovascular health or a heightened awareness of their individual cardiovascular risk.

Screening was conducted in 2 nontraditional forums: the student recreation center and the student dining hall. These forums were convenient to students and allowed maximum participant capture over a short period of time; unfortunately, these settings were not ideal for measurements. The original intent was to take 2 standardized BP measurements (at rest and in a seated position); however, unanticipated space limitations, time limitations, and a lack of seating prevented standardized measurements. The research team was advised on arrival to the test site that no seating would be allowed, as this would confer an unfair advantage compared to other exhibitors. Therefore the BP data were limited to a

| Risk measure                      | Prevalence (%) | Male versus female RR (95% CI) | Black versus white RR (95% CI) | Black men versus white men RR (95% CI) | Black women versus white women RR (95% CI) |
|-----------------------------------|----------------|--------------------------------|--------------------------------|----------------------------------------|-------------------------------------------|
| Reported hypertension             | 14 (2.7)       | 1.17 (0.42–3.31)               | 4.02 (1.31–12.3)               | 8.17 (1.43–46.79)                      | 2.29 (0.46–11.44)                         |
| Reported diabetes                 | 7 (1.3)        | 0.26 (0.03–2.14)               | 1.4 (0.16–12.4)                | 1.77 (0.07–42.35)                      | 1.91 (0.0–17.94)                         |
| Family history of cardiovascular disease | 46 (8.8)      | 0.73 (0.39–1.34)               | 0.94 (0.41–2.14)               | 0.99 (0.23–4.24)                       | 0.92 (0.34–2.51)                         |
| Smoker                            | 68 (13.0)      | 1.75 (1.12–2.73)               | 0.46 (0.19–1.1)                | 0.34 (0.09–1.34)                       | 0.59 (0.19–1.86)                         |
| Sedentary lifestyle               | 142 (27.0)     | 0.55 (0.4–0.77)                | 1.23 (0.84–1.8)                | 1.01 (0.43–2.38)                       | 1.43 (0.97–2.11)                         |
| BMI ≥ 25                          | 146 (27.8)     | 1.39 (1.06–1.83)               | 1.74 (1.27–2.39)               | 1.78 (1.16–2.72)                       | 1.7 (1.07–2.66)                          |
| BMI ≥ 30                          | 38 (7.2)       | 1.4 (0.76–2.58)                | 3.93 (2.08–7.43)               | 2.18 (0.73–6.46)                       | 5.73 (2.53–12.95)                       |
| SBP ≥ 140 mmHg                    | 41 (7.8)       | 3.76 (1.96–7.2)                | 1.66 (0.79–3.52)               | 0.78 (0.25–2.44)                       | 4.77 (1.52–14.97)                       |
| DBP ≥ 90 mmHg                     | 29 (5.5)       | 1.67 (0.82–3.39)               | 2.5 (1.13–5.53)                | 3.03 (1.09–8.39)                       | 1.91 (0.54–6.78)                        |
| Nonfasting BG ≥ 140 mg/dL         | 45 (8.6)       | 1.63 (0.93–2.84)               | 0.30 (0.07–1.23)               | 0.57 (0.13–2.33)                       | 0.15 (0.01–2.48)                        |
| HDL ≤ 50 mg/dL for females        | 97 (18.5)      | 1.07 (0.67–1.71)               |                               |                                        |                                           |
| HDL ≤ 40 mg/dL for males          | 48 (9.1)       | 0.39 (0.13–1.17)               |                               |                                        |                                           |

Note. BG, Blood glucose; BMI, Body Mass Index; CI, confidence interval; DBP, diastolic blood pressure; HDL, high-density lipoprotein; RR, relative risk; SBP, systolic blood pressure.
We recognize this as a major flaw in methodology, but rather than discard these data, we have tried to present them in a way that mitigates these effects. Only measurements at or above the Stage I hypertensive range were interpreted to convey BP risk. In addition, a substudy conducted among the 100 participants screened in the dining hall demonstrated good concordance between initial standing and subsequent seated resting BP measurements.

Blood measurements were limited to nonfasting, random finger-stick measurement of blood lipids and BG. Use of finger-stick blood testing, although potentially less accurate than venous blood draws, is the method most often used in large-scale screening and allows real-time, onsite feedback to participants regarding their individual cardiovascular risk profile. Most students reported at least 4 hours of fasting; however, as there was no standard fasting period, there could be overestimation of glyceremic risk. Measurement of postprandial lipids, although nonstandard, is gaining credence in the medical community due to large studies among young adults demonstrating a strong correlation of postprandial TG and HDL levels with elevated cardiovascular mortality [32-35].

In general these factors tend to bias towards overestimation of risk and may lower the specificity, but not necessarily the sensitivity, of screening results. Despite these limitations, by assessing the prevalence of multiple risk factors and metabolic criteria, we were able to identify a subset of students who could benefit from further medical follow-up.

Conclusion

In North Carolina, cardiovascular disease ranks fifth in all-cause mortality of individuals between the ages of 15–34 years, and it ranks third among factors for loss of productive years before the age of 65 years. Although ECU undergraduates have a high prevalence of multiple risk factors, the detected rates of individual risks were lower overall than those found in young adults across the United States [15]. Considering that ENC has a disproportionately high burden of cardiovascular disease, stroke, and obesity-related diabetes among adults [11], this represents a promising area of opportunity for intervention to prevent disease.

In the ECU Heart Healthy cohort, we found several areas of risk that merit further focus, including inactivity among female students, especially black females; the lack of a cardioprotective effect of athletic participation and highest levels of physical activity; and discordance between perceived and actual health status among ECU undergraduates. Other findings of interest, such as the high prevalence of metabolic syndrome among black students and diastolic BP elevation among black males, require recruitment of larger numbers of these subpopulations for validation.

Young adults enrolled in higher education represent a population in which preventive cardiovascular interventions can be easily tested. Understanding the perspective and behavioral motivation of young adults is key to impacting their long-term cardiovascular health. How risk stratification is presented to this cohort may impact whether a change in behavior results. Development of strategies to effectively alter risk perceptions in young adults and to effect durable lifestyle changes remains a challenging goal.

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