Hypertension in Healthy College Students: The Hypertension in Young Adults (HiYA) Study

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ABSTRACT

Introduction/Purpose: The 2017 American College of Cardiology/American Heart Association (ACC/AHA) Hypertension Guidelines lowered the threshold for hypertension, and more individuals are likely to be diagnosed with elevated blood pressure (BP; 120–129/<80 mm Hg) or hypertension (stage 1, 130–139/80–89 mm Hg; stage 2, ≥140/90 mm Hg). Prevalence of hypertension in the lower end of the young adult/college-aged group aged 18–24 yr is not well characterized and how the revised guidelines apply to this age group has not yet been studied. Therefore, the primary purpose of this study was to determine the potential prevalence of hypertension in a population of healthy college students using the 2017 ACC/AHA Hypertension Guidelines. **Methods:** Resting BP was measured in 87 individuals (20.7 ± 1.7 yr, 49 females (F), 38 males (M)) using the auscultatory method according to American Heart Association guidelines. The average of two readings was used. **Results:** Forty-seven (32 F, 15 M) participants had normal (<120/<80 mm Hg) BP. Twenty participants (10 F, 10 M) had elevated BP (systolic BP (SBP), 122.4 ± 2.9; diastolic BP (DBP), 72.8 ± 6.2 mm Hg), and 20 were classified as in either stage 1 (n = 14: 5 F, 9 M; SBP, 125.3 ± 7.1; DBP, 82.7 ± 6.8 mm Hg) or stage 2 (n = 6: 2 F, 4 M; SBP, 141.3 ± 9.8; DBP, 86.2 ± 13.4 mm Hg) hypertension categories. **Conclusions:** Under the 2017 guidelines, 46% of the study population was classified in the elevated BP or hypertensive categories, revealing a much-higher-than-expected potential prevalence in this apparently healthy, physically active population of college students. More educational efforts are needed to promote hypertension awareness among college students.

INTRODUCTION

Hypertension (high blood pressure (BP)) is a major public health concern in the United States and is a key risk factor in the development of cardiovascular disease (CVD). In fact, higher-than-normal BP is considered to be the largest contributing risk factor to all-cause and cardiovascular mortality (1). BP is considered to be normal with a systolic pressure of <120 mm Hg and diastolic pressure of <80 mm Hg (2,3), and as systolic and/or diastolic pressures exceed the normal range, they are classified into clearly defined categories of hypertension. The guidelines for hypertension classification changed significantly in 2017 (summarized in Fig. 1), lowering the threshold for hypertension classification (3). Under the previous guidelines for hypertension (Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-7)), the prevalence of hypertension in US adults in general was 31.9%, but under the 2017 American College of Cardiology/American Heart Association (ACC/AHA) Guideline for the Prevention, Detection, Evaluation and Management of High Blood Pressure in Adults, prevalence is currently 45.6%, a substantial increase of 13.7% (4).

Although it is well known that hypertension is most prevalent in the 60+-yr age group (~63%, under the previous guidelines) and least prevalent in adults 18–39 yr old (~8%) (5), much less is known about the prevalence in the younger end of the latter group. Many investigations of hypertension and other CVD risk factors have indeed studied young adults, but the age range is often ~18–30 yr (6–8). Far fewer studies have examined hypertension among college students, who are generally in the age range of 18–24 yr; this is probably because individuals in this age group are assumed to be generally healthy and have no or few other risk factors. Understanding the prevalence of all categories of hypertension in this population is important from a public health standpoint, given that recent evidence has shown that having above-normal BP in early adulthood is associated with greater risk of CVD later in life (6,9,10). Zhang and colleagues (10) reported that higher-than-normal BP levels before the age of 40 yr raises the risk of developing heart disease later in life; having a systolic BP (SBP) of ≥130 mm Hg was associated with a 37% increased risk of heart failure, and having a diastolic BP (DBP) of ≥80 mm Hg was associated with a 21% increased risk, highlighting the importance of identifying elevated BP and hypertension early among young adults.

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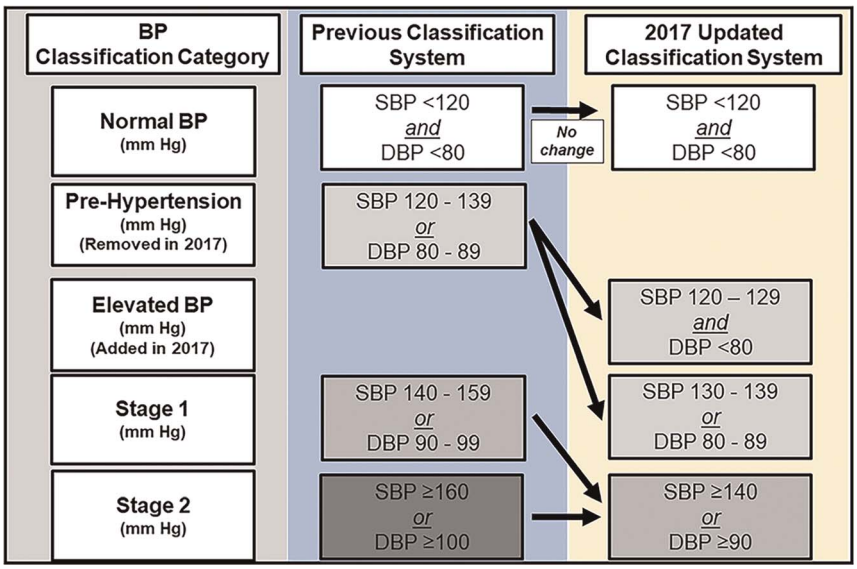

Figure 1: Comparison of the previous JNC-7 hypertension classification guidelines (2) and the 2017 ACC/AHA Guideline for the Prevention, Detection, Evaluation and Management of High Blood Pressure in Adults hypertension classification guidelines (3).

Given that the new guidelines lowered the threshold for hypertension classification, it is possible that the prevalence of hypertension in the college-aged population could significantly increase. Identifying those at risk for hypertension in this age group holds considerable public health importance, because intervening in the development or progression of hypertension at a younger age through education and awareness, and implementation of health-promoting lifestyle changes could lead to lowered overall CVD risk and improved health outcomes as this population ages. Therefore, the Hypertension in Young Adults (HiYA) study was conducted to determine the potential prevalence of each hypertension category using the new 2017 ACC/AHA guidelines in a sample of healthy, physically active college students aged 18–24 yr.

METHODS

Participants

All participants were recruited via email, fliers, and word-of-mouth at Hamline University. Individuals were included in the study if they were between the ages of 18 and 24 yr, considered generally healthy, and either recreationally active (2–3 $h \cdot wk^{-1}$ of physical activity and/or exercise) or highly active/athletes (>3 $h \cdot wk^{-1}$ of physical activity and/or exercise, or being a competitive athlete). Individuals were excluded from participation if they were currently taking any medication known to affect BP (birth control pills, nonsteroidal anti-inflammatory drugs, BP-lowering medications, stimulant medications). All participants were asked to refrain from exercising for 4 h and from having caffeine or other stimulants for at least 2 h before the test session. All participants provided voluntary written informed consent, and the study was approved by the Hamline University Institutional Review Board (IRB No. 2018-219-UB).

Assessments

Most of the test sessions were held in the Integrative Physiology Laboratory, but some were conducted in the university's gymnastics gym, a location that was more convenient for some of the participants. The gym was used during nonpractice hours, and no other individuals were in that space during the study test sessions. The same equipment was used in each location by trained laboratory assistants, and identical BP measurement procedures were followed in both locations. Upon arrival to the laboratory or gym, compliance with inclusion and exclusion criteria (described previously) was verified via self-report. Each participant's height and weight were measured, and body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. A brief health history questionnaire was completed. Participants also answered questions regarding their physical activity and exercise status.

BP Measurement

After sitting for 10–15 min, BP was measured using an aneroid sphygmomanometer and cuff unit and stethoscope (Diagnostix 752M unit and ADC 603 stethoscope, American Diagnostic Corp., Hauppauge, NY) according to the American Heart Association guidelines for BP measurement (11). The average of the two readings was recorded as the individual's resting BP.

Resting Heart Rate

After taking each BP measurement, resting heart rate (RHR) was measured manually by palpating the radial artery. Heart beats were counted for 30 s and multiplied by 2 to determine beats per minute. The average of the two measures was used.

BP Classification

Each participants' BP was categorized as normal (NBP), elevated BP (EBP), stage 1 hypertension, or stage 2 hypertension using the 2017 ACC/AHA guidelines as shown in Fig. 1. For more accurate analyses, we combined the stage 1 and 2 groups into one hypertension group (HYP). Because we measured BP in one session only, and not the 2 or more separate sessions necessary to formally classify an individual as having hypertensive BP, we termed this potential prevalence rather than simply prevalence.

To compare potential prevalence under the previous and the 2017 guidelines, the classification process was repeated using the

JNC-7 guidelines and categories of normal, prehypertension, stage 1 hypertension, or stage 2 hypertension (shown in Fig. 1).

Statistical Analysis

One-way ANOVA was used to determine differences between classification category groups for age, height, body mass, BMI, SBP, DBP, and RHR. Ordinal logistic regression analysis was performed to examine the relationship between the independent predictor variables of sex, BMI, and participation in resistance training, which was included as a variable because regular participation in resistance training is associated with higher BP than endurance training (23). All analyses were conducted using SPSS software, version 26 (IBM Corp., Armonk, NY). Means and SD are reported for all variables. The significance level was determined at $P < 0.05$.

RESULTS

Participant Characteristics

The characteristics of the study population as a whole, as well as grouped according to the 2017 ACC/AHA BP classification categories, are shown in Table 1. Despite all participants being in the age range of 18–24 yr, those who were classified in the HYP group were older than those in the NBP or EBP groups (Table 1; $F(2,84) = 6.37$, $P < 0.02$).

Body Mass, Height, and BMI

As shown in Table 1, both the EBP and HYP groups had significantly higher body mass than those in the NBP category ($F(2,84) = 10.7$, $P < 0.04$). There was no difference in height between groups. BMI was significantly higher in HYP compared with the NBP group ($F(2,84) = 7.8$, $P < 0.001$), but was not different from the EBP group (Table 1). Although the higher BMI of the EBP group was not statistically different from the NBP group, the difference approached significance at $P = 0.072$.

SBP and DBP

Table 1 shows the values for SBP and DBP in the overall study population as well as according to each 2017 ACC/AHA classification category. As expected, significant differences in both SBP and DBP existed between each category/group ($P < 0.009$ for all comparisons). Although this is not shown in Table 1, 14 of the 20 individuals in the HYP category were classified as stage 1 (means, 125.3 ± 7.1 mm Hg for SBP and 82.7 ± 6.8 mm Hg for DBP), and 6 were classified as stage 2 (means, 141.3 ± 9.8 mm Hg for SBP and 86.2 ± 13.4 mm Hg for DBP).

Resting Heart Rate

There were no differences in RHR between groups (Table 1; $F(2,84) = 1.9$, $P = 0.80$).

Potential Prevalence of EBP and Hypertension

Fig. 2 shows the potential prevalence of each hypertension category under the 2017 ACC/AHA guidelines (panel A) and under the previous JNC-7 guidelines (panel B). We split the HYP group ($n = 20$) into the respective stage 1 ($n = 14$) and stage 2 ($n = 6$) hypertension categories for prevalence analysis and comparison. Compared with the classification using the previous guidelines, the potential prevalence of stage 1 hypertension increased by 9.2% (from 6.9% to 16.1%), whereas the potential prevalence of stage 2 increased by 6.9% using the 2017 ACC/AHA guidelines. Under the previous guidelines, no participants were classified as stage 2, but under the new 2017 guidelines, six individuals were in this category.

Relationship between Predictor Variables and BP Classification Category

In the ordinal logistic regression analysis, sex, BMI, and participation in resistance training were entered as predictor variables, and a significant likelihood ratio test ($P = 0.001$) indicated that this model was an improvement in fit relative to

TABLE 1.
Participant Characteristics and BP Classification, Using the 2017 ACC/AHA Hypertension Guidelines.

	All Participants (n = 87)	Normal BP (n = 47)	Elevated BP (n = 20)	Hypertension (n = 20)
Age (yr)	20.7 ± 1.7	20.4 ± 1.5	20.4 ± 1.6	21.8 ± 1.8*,**
Sex (n)				
Female	49	32	10	7
Male	38	15	10	13
Height (cm)	172.4 ± 10.6	169.7 ± 8.7	175.5 ± 11.8	175.5 ± 12.0
Mass (kg)	73.8 ± 14.3	68.3 ± 10.8	76.9 ± 10.6*	83.7 ± 18.5*
BMI ($kg \cdot m^{-2}$)	24.7 ± 3.4	23.6 ± 2.6	25.0 ± 3.3	27.0 ± 4.3*
SBP (mm Hg)	117.9 ± 10.5	110.9 ± 5.4	122.4 ± 2.9*	130.1 ± 10.8*,**
DBP (mm Hg)	72.4 ± 10.1	67.4 ± 7.8	72.8 ± 6.2*	83.8 ± 9.1*,**
RHR (bpm)	70.7 ± 10.5	69.7 ± 9.6	69.0 ± 9.8	74.7 ± 12.6

Values are means ± SD.
*$P < 0.05$ versus normal.
**$P < 0.05$ versus elevated BP.

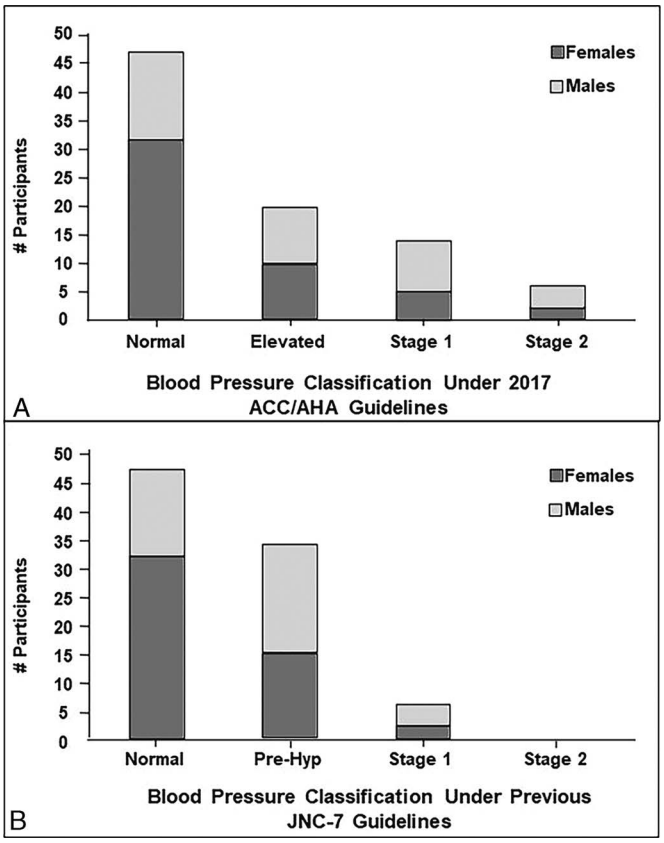

Figure 2: Potential prevalence of each hypertension category in the study population according to the new and the previous guidelines. Distribution of participants in each category is shown by sex. A, Potential prevalence under the 2017 ACC/AHA guidelines. B, Potential prevalence under the previous JNC-7 guidelines.

the null/intercept only model. Nonsignificant goodness-of-fit tests further indicated that this model was a good fit for the data. The analysis revealed that BMI was a significant predictor of BP classification category (estimate, 0.189; 95% confidence interval, 0.047–0.332; $P = 0.009$). Sex and participation in resistance training were not significant predictors of BP classification category in the model. (The initial correlations between the predictor variables and BP classification category were as follows: BMI, 0.369; sex, 0.270; and participation in resistance training, –0.195.)

DISCUSSION

The present study aimed to determine the potential prevalence of hypertension using the new 2017 ACC/AHA guidelines in a sample of healthy, physically active college students aged 18–24 yr. The most noteworthy finding was that in this population, which would seem to be at low risk of hypertension, 23% had EBP, and another 23% had either stage 1 or stage 2 hypertension-level BP, which was much higher than expected. To our knowledge, this is the first study to examine the potential prevalence of hypertension in college-aged undergraduate students using the new 2017 ACC/AHA guidelines. Using the previous guidelines, a study of 525 undergraduates at a university in North Carolina reported a 10.5% prevalence of hypertension, which was classified as either ≥140 mm Hg SBP or ≥90 mm Hg DBP (12); however, under the new guidelines, that BP range would now be classified as stage 2 hypertension, and far more individuals would likely fall into the EBP and stage 1 categories. Thus, the potential prevalence results in our study are likely in a realistic range.

Our findings are important from a public and college health standpoint because early identification of hypertension is essential to reduce CVD risk as these individuals age. Identifying elevated or high BP earlier in adulthood holds significant secondary prevention potential, given that having higher-than-normal BP in early adulthood is associated with greater risk of CVD later in life (6,9,10,13,15,16). The Harvard Alumni Health Study, a prospective cohort study of over 18,000 male Harvard University entrants, examined the association of BP at college entry (mean age, 18.3 yr) with all-cause mortality and CVD (9). Physician-diagnosed hypertension status was then assessed decades later, at a mean age of 45.8 yr; participants were then followed for approximately 36 more years and assessed for any cardiovascular diagnoses and events, and all-cause mortality (9). Results showed that higher BP in early adulthood was associated with greater risk of all-cause mortality and CVD, several decades later (9). Although the Harvard Alumni Health Study may not be generalizable to a wider population, it is still demonstrative of the association between higher BP at college entry and health events later in life, highlighting the importance of early detection of hypertension during the college years.

Hypertension in the college age range of 18–24 yr is certainly understudied. Although several studies have examined BP in "young adults," that age range is usually far broader. Some have defined the young adult age range as 18–30 yr (6,7, 13), whereas others use 20–34 (8) or 18–39 yr (14). Importantly,

hypertension prevalence has been reported in previous investigations to be 15.8% for the age group of 20–34 yr (8) and 7.5% for the broader age group of 18–39 yr (5). Therefore, our study adds valuable knowledge about possible hypertension prevalence in the understudied population of 18–24 yr of age.

It is important to understand that many factors contribute to increased BP in college-aged adults/students, some of which are common across all age groups. Race is a major factor, and although it is well established that there is a higher prevalence of hypertension in Blacks than in Whites (5), a recent investigation of the cumulative incidence of hypertension from age 18 to 55 yr among participants in the Coronary Artery Risk Development in Young Adults (CARDIA) study expanded on this knowledge by showing that racial differences in hypertension prevalence emerged before the age of 30 yr (17). Among the undergraduates in the study conducted by Lai et al. (12), Black males had a significantly greater risk of hypertension compared with White males. Taken together, these two previous studies emphasize the need for early detection and intervention, particularly in non-White populations.

Other common risk factors for hypertension in college students, as well as among adults in general, include lifestyle factors such as tobacco use, use of nonsteroidal anti-inflammatory drugs and birth control pills (18,19), white coat hypertension/syndrome (20), and heavy alcohol consumption (21). Participating in specific sports is also associated with higher BP, and football is the sport most often associated with increased BP and hypertension in college athletes (22). In the present study, only 5 of our 87 participants were football players and were not clustered in any one BP category; therefore, we cannot draw any conclusions regarding football and BP in college athletes. Participating regularly in resistance training is associated with higher BP than participation in endurance training (23), but our regression model did not find a significant association of resistance training participation and BP category in our study.

Our regression model did show that of the independent predictor variables of sex, participation in resistance training, and BMI, only BMI was significantly predictive of BP category. Although this finding may seem to agree with that of Lai et al. (12), who reported that the most common individual risk factor for hypertension in their study population of undergraduate students was a BMI $\geq$25 kg·m^{-2}, a more thorough examination of BMI as an appropriate predictor must be considered. About 27% of the participants in their study had a BMI $\geq$25 kg·m^{-2} (12), and in the present study, both the EBP and HYP categories had BMIs $\geq$25 kg·m^{-2}; however, 27% of participants in Lai and colleagues' study were sedentary, whereas all of our participants were either recreationally active or highly active/competitive athletes. This points out the problem with using BMI as a predictor of BP classification category: as an indirect measure of body fatness, BMI does not take an individual's actual body fat percentage versus lean mass into account and is not accurate across all populations, including athletes (24–26). Individuals who have greater fat-free mass relative to height, which is common in highly active individuals, athletes, and healthy younger adults, may be erroneously classified as overweight or even obese despite the fact that they have relatively low levels of body fat (24,26). Therefore, more risk factors than BMI alone should be considered when evaluating an individual's overall risk of hypertension.

In addition to our primary aim of determining the potential prevalence of elevated BP and hypertension in our college student population, we also compared potential prevalence using the 2017 ACC/AHA guidelines with that obtained by using the previous guidelines. It should be noted that under the previous guidelines, individuals with SBP of 120–139 mm Hg or DBP of 80–89 mm Hg were considered to be prehypertensive (2). Under the new guidelines, the prehypertensive category was eliminated, and the category of elevated BP was introduced, defined as SBP of 120–129 mm Hg and DBP of <80 mm Hg (3). Therefore, individuals with SBP of 130–139 mm Hg or DBP of 80–89 mm Hg now fall into the stage 1 hypertension category under the new guidelines. In the present study, all 14 individuals in the stage 1 category under the 2017 ACC/AHA guidelines would have previously been classified as prehypertensive, and under the previous guidelines, none of the participants would have been classified in the stage 2 category; however, under the 2017 guidelines, 6 individuals met the stage 2 hypertension classification criteria. Supporting our findings of increased potential prevalence of hypertension in the young adult population (although using a broader age range) are those of Muntner et al. (4), who found that in the age group of 20–44 yr, prevalence of hypertension increased from 10.5% under the previous guidelines to 24.0% under the 2017 guidelines, leading the authors to conclude, as do we, that the new guidelines will result in a substantial increase in the prevalence of hypertension among US adults, including those at the younger end of the adult age spectrum.

The present study has several strengths and limitations. Although BP studies often use data collected at screening events (12), sports physical examinations (22,27), or from cohort studies (6,10), we aimed to reduce potential confounding factors that could impact BP by using strict inclusion and exclusion criteria that should reduce variability among participants. The test sessions were performed under well-controlled conditions, and the AHA guidelines for BP measurement were strictly followed. Therefore, we are confident that the BP values reported in this study are accurate and not significantly influenced by measurement error and common confounding factors.

One limitation of our study is that, although we are categorizing individuals according to BP category and reporting potential prevalence in those categories, we cannot determine the true prevalence of hypertension in our study population because our measurements were taken in a single session; official classification/diagnosis of hypertension categories is usually based on an average of two or more seated BP measurements, taken at each of two or more office visits/sessions (3). However, many previously published studies of BP in young adults have also assessed BP at only one time point yet reported prevalence in each category (12,22,27,28). Another limitation is the lack of racial and ethnic diversity in our study population. Because ~83% of our participants were White (n = 72 out of 87; only 5 were Black, 5 were Hispanic, and 5 were Asian), we cannot analyze racial or ethnic differences, nor can we generalize our findings to non-White populations. Given that prevalence of hypertension has been shown to differ significantly among these groups (5), future research must aim to include a more diverse population. In addition, a broader population from multiple colleges and universities across a larger geographic area would shed more light on this issue and allow for more statistical power overall.

From a practical standpoint, our findings underscore the critical need to increase hypertension and CVD risk awareness,

educational campaigns, and interventions on college campuses. Because students with elevated or higher BP are at higher risk of developing hypertension and CVD as they age, it is critical that the administrators and staff of health services and wellness centers, as well as athletic training staff and team medical personnel, develop and implement educational programs and on-campus interventions that target hypertension and CVD risk awareness and reduction.

CONCLUSIONS

The potential prevalence of EBP and stage 1 and 2 hypertension was much higher than expected in this apparently healthy, physically active population of college students. Our findings suggest that college students should be targeted for hypertension and CVD risk reduction educational campaigns and interventions in order to reduce their risk of developing CVD as they age.

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