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Abstract

Background: The diagnostic criteria for hypertension have recently been redefined by the American College of Cardiology/American Heart Association (ACC/AHA). Data on the new prevalence of hypertension in different countries are emerging, but none, to date, from Saudi Arabia.

Aim: This study aimed to determine the impact of the 2017 ACC/AHA hypertension guideline on the prevalence and determinants of hypertension in young Saudi women.

Methods: 518 female college students, 17–29 years of age were prospectively enrolled in a survey during the period from January 1, 2016, to April 15, 2016 at Princess Nourah University. The participants completed a previously validated questionnaire, that assessed their risk factors for hypertension, and their blood pressure, weight and height were measured.

Results: Application of the 2017 ACC/AHA diagnostic criteria resulted in approximately 7-fold increase in the prevalence of hypertension, from 4.1% to 27.1% (P < 0.001). At a cut-off value of ≥140/90, hypertension was significantly associated with increased age, increased body mass index (BMI), increased heart rate, history of chronic illnesses, prior diagnosis with diabetes mellitus and family history of hypertension. Whereas, with the ≥130/80 cut-off value, only increased BMI and heart rate were significant predictors (P < 0.001).
Conclusion: The prevalence of hypertension markedly increased among young adult Saudi women with the 2017 ACC/AHA classification for hypertension, and the main predictors were increased BMI and heart rate. Further studies on the new prevalence and predictors of hypertension in the Saudi population are warranted. This information is important for healthcare authorities to plan cost effective screening, prevention and control programmes.

Keywords: hypertension, ACC/AHA diagnostic criteria, prevalence, predictors, women

Citation: Al-Mohaissen MA; Al-Obaid QY; AlGhamdi WA; Al-Alyani HS; Dahman SM; Al-Wahhabi NA; et al. Impact of the 2017 American College of Cardiology/American Heart Association Hypertension Guideline on the prevalence of hypertension in young Saudi women. East Mediterr Health J. 2019;25(x):xxx–xxx. https://doi.org/10.26719/emhj.19.080

Received: 03/07/18; accepted: 26/02/19

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Introduction

The American College of Cardiology/American Heart Association (ACC/AHA) recently redefined the thresholds for the diagnosis of hypertension in adults. The new diagnostic cut-off value of \( \geq 130/80 \) mmHg is to replace the previous JNC7 threshold of \( \geq 140/90 \) mmHg for the diagnosis of hypertension (1). While the 2017/ACC/AHA guideline recommends lifestyle modification for all hypertensives, it only recommends blood pressure (BP)-lowering medications for adults with stage 1 hypertension, for secondary prevention in patients with clinical cardiovascular disease or for primary prevention in adults with an estimated 10-year atherosclerotic cardiovascular disease risk of \( \geq 10\% \), and those with stage 2 hypertension (1).

Accumulating evidence has shown that reduction of systolic BP to a target of \(< 130 \) mmHg significantly decreases the risk of myocardial infarction, stroke, heart failure and major cardiovascular events in adults (2). Implementation of the 2017/ACC/AHA hypertension
Studies on the prevalence of hypertension in Saudi Arabia have all used the previous diagnostic thresholds of \( \geq 140/90 \) mmHg. A prevalence of 26.1–27.2\% among Saudis aged \( \geq 30 \) years was found (12,13) and 15.2\% in those aged 15 years or older (13). For the 15–24 years age group, a prevalence up to 8.8\% was reported (14). These estimates are expected to be higher had the \( \geq 130/80 \) mmHg thresholds been used. The magnitude of increase in the prevalence in hypertension in SA with the new ACC/AHA guideline is unknown to date.

In this study we aimed to assess the effect of the 2017/ACC/AHA hypertension guideline on the prevalence of hypertension and predictors of hypertension in young Saudi women.

**Methods**

**Study population**

We re-analysed the data of 518 adult Saudi females aged 17–29 years who participated in a hypertension survey conducted in 2016 on undergraduate and postgraduate students at Princess Nourah bint Abdulrahman University, Riyadh. We evaluated the change in the prevalence of hypertension among these young women following the introduction of the 2017/ACC/AHA guideline using the new thresholds (15).

The participants were enrolled prospectively during the period from 1 January 2016 to 15 April 2016. The sampling is detailed in the original study (15). With 530 participants, the estimated prevalence would be expected to have a precision of 2\% with alpha 0.05 (16). Those diagnosed with cardiac disease and pregnant women were excluded.

Questionnaire and data collection
The questionnaire and method of data collection has been described previously (15). In brief, following approval of the study by our Institutional Review Board, the students were invited to participate in the study. Participation was voluntary, and the study followed the principles of the Helsinki Declaration. An anonymous self-administered questionnaire was distributed (13) [the questionnaire was part of the Saudi Health Interview Survey (17)]. The final questionnaire comprised 65 questions assessing sociodemographic characteristics, BP history and risk factors for hypertension.

The participants’ BP, heart rate, weight, and height were measured and recorded on entry to the study. For BP measurement, we followed The National Health and Nutrition Examination Survey instructions. The Omron M6 Comfort (HEM7223-E) automated BP device was used. Three brachial BP readings were taken at 5 minute intervals for each participant while resting. The first reading was discarded and the second and third readings were averaged and recorded. In cases where only 2 readings were available, the second reading was recorded (18).

Statistical analysis

Data analysis was performed using SAS, version 9.4. Continuous variables are reported as means and standard deviations (or medians and interquartile ranges as appropriate) and categorical variables as numbers and percentages. Comparisons between the hypertension and normal groups were performed using the Chi-squared test, Fisher’s exact test, t-test, or the Wilcoxon rank sum test as appropriate. We compared the difference in the prevalence of hypertension as diagnosed via the 2017/ACC/AHA and the JNC7 guidelines using McNemar’s test (due to matched pairs of women across the 2 guidelines). A P-value < 0.05 was considered statistically significant.

Results

A total of 530 students were enrolled in the initial survey. Twelve participants (2.3%) had undetermined BP status (BP measurements were taken but they omitted to answer the question regarding being on treatment for hypertension) and were excluded. The baseline characteristics of the remaining 518 participants are displayed in Table 1. Table 2 shows the new analysis of the BP and heart rate results according to the new 2017/ACC/AHA guidelines. All the hypertensives (those on treatment for hypertension or with BP ≥ 130/80) had elevated their diastolic BP (mean 83.3 mmHg, range 73.5–107.0 mmHg). None of the hypertensive subjects had a systolic BP ≥ 130 mmHg.
The prevalence of hypertension in the study population according to the 2017/ACC/AHA and JNC7 guidelines is shown in Table 3. According to the 2017/ACC/AHA classification, 27.1% of participants would be classified as having hypertension, which was significantly higher than the prevalence of 4.1% if the JNC7 classification was applied (P < 0.001). We found that 85% of the hypertensives in the study had stage 1 hypertension (systolic BP = 130–139 mmHg and/or diastolic BP = 80–89 mmHg), and 15% had stage 2 hypertension (BP ≥ 140/90 mmHg). All of the 119 participants with stage 1 hypertension according to the 2017/ACC/AHA guideline also fulfilled the JNC7 criteria for prehypertension (systolic BP = 120–139 mmHg and or diastolic BP = 80–89 mmHg) (Table 3).

Table 4 shows the predictors of hypertension in the study population according to the JNC7 and 2017/ACC/AHA guidelines. At a cut-off value of ≥ 140/90, significant predictors of hypertension were increased age, body mass index (BMI) and heart rate; known diabetes; and family history of hypertension. Prior diagnosis of chronic disease was more common in the hypertension group, 23.8% vs 10.3% (P = 0.05). The percentage of participants who exercised regularly was lower in the hypertension group but this was not statistically significant (23.1% vs 30.0%, P = 0.592). None of the dietary constituents had an association with hypertension. When analysed using the 2017/ACC/AHA cut-offs, only BMI and heart rate emerged as statistically significant. There was no association between hypertension and other established risk factors for hypertension, including diabetes mellitus, age, family history, or exercise. None of the studied dietary constituents had an association with hypertension (Table 4).

**Discussion**

**Prevalence of hypertension according to the 2017/ACC/AHA guideline**

The results of this study show an approximately 7-fold increase in the prevalence of hypertension among young Saudi women with application of the 2017/ACC/AHA thresholds for hypertension diagnosis. A significant absolute increase of 23% is observed using the 2017/ACC/AHA guideline compared with the JNC7 guideline (27.1% vs 4.1% respectively (P < 0.001)), representing an increase in newly diagnosed stage 1 hypertension cases. As would be expected in a young population, diastolic hypertension predominated, and in our sample, all the hypertension cases were comprised of isolated diastolic hypertension. To our knowledge, this is the first study to report on the new prevalence of hypertension in a subset of the Saudi population following the introduction of the 2017/ACC/AHA guideline and to study hypertension prevalence in this age group.

The magnitude of the increase in the prevalence of hypertension as defined by the 2017/ACC/AHA guideline, varies between countries. In the United States of America, the crude prevalence of hypertension among adults increased to 45.6% with implementation of the
2017/ACC/AHA hypertension guideline, with an absolute increase of 13.7% compared to the JNC7 guideline (6). In India and Canada absolute increases of 14% are expected with the new classification (4,11); and increases of 25–50% and 36–58% are anticipated in China and Japan respectively (10,19). To our knowledge, there are no studies to date on the new prevalence of hypertension among young adults to compare our results to. However, we believe that the magnitude of increase we found likely represents a true increase since our finding based on JNC7 criteria was 4.1%, which is within the results reported by other studies involving Saudi youths (2.5–8.8% ) (13,14). As the Saudi population currently comprises mainly young individuals (20), these findings may translate into a significant rise in the proportion of hypertensive Saudis. Considering that women are at a lower risk of hypertension (12) compared with males, we expect that these figures will be higher when young male subjects are studied.

As a youthful population is expected to be at low cardiovascular risk, it is likely that only a few of the newly diagnosed hypertensives will require antihypertensive therapy (6).

**Predictors of hypertension according to JNC7 and 2017/ACC/AHA classifications**

In addition to increasing the prevalence of hypertension, lowering the diagnostic thresholds altered the predictors of hypertension in our study. With application of the JNC 7 classification, significant predictors of hypertension were increased age, increased BMI, increased heart rate, history of diabetes, and family history of hypertension. These findings are in accordance with the known risk factors for hypertension, and their relation to hypertension has been discussed in detail previously (1). However, predictors of hypertension with the lower 2017/ACC/AHA guideline criteria were limited to increased BMI (P < 0.001) and increased heart rate only. These 2 risk factors are unique: the association of increasing BMI with hypertension bears a continuous, almost linear, relationship, with no evidence of a threshold (1), while increased heart rate implies dominance of the sympathetic over the parasympathetic nervous systems, a mechanism that leads to both accelerated heart rate and raised BP (21). Increased heart rate often predated the development of hypertension in previous studies (22).

While the number of participants who consumed ≥ 5 servings of fruits and vegetables per day was higher in the no hypertension group in both the 2017/ACC/AHA and JNC7 comparisons [7 (13.2%) vs 20 (17.9%), and 27 (17.0%) vs 0 (0.0%) respectively], this was not statistically significant (P= 0.608 and 0.670 respectively). This finding is likely due to the poor accordance with the DASH (Dietary Approaches to Stop Hypertension) diet observed in our population as a whole, as in this dietary pattern 4–5 servings each of vegetables and fruits are recommended (23). None of the comparisons for the other components of the DASH diet reached statistical significance in our study. More research involving larger samples is necessary to establish the efficacy of the DASH diet in young Saudis with formal calculation of the DASH score. Of interest, it was recently reported that among children and adolescents, despite a significant inverse relationship between the DASH score and systolic BP, there is no significant association between this dietary pattern and diastolic BP (24), which is commonly involved in hypertension in the young. Additionally only a small proportion of the participants had hypertension risk factors, including diabetes, dyslipidaemia and a positive family history, and only about one-third...
of the participants exercised 3–5 times/week. These results also require re-evaluation in larger samples to establish their effect on the new hypertension thresholds.

Other potential explanations for the lack of association of the 2017/ACC/AHA stage 1 hypertension with well-established predictors, observed in our study, may be due to the nature of the studied population and the BP cut-off values. Our sample comprised young and mostly healthy females. In such a population, some risk factors may be of greater significance compared to others, obesity particularly. Although multivariate analysis was not performed in our study, Obarzanek et al, evaluating the individual components of multiple behaviour changes, found that while several lifestyle behaviour changes are important for reduction of BP, they were difficult to detect when weight was included in multivariate models (25). It is also important to note that, the “blood pressure zone” termed prehypertension in the JNC7 guideline is currently unequally split in the 2017/ACC/AHA classification between high normal BP and stage 1 hypertension. In our study, 100% of those with stage 1 hypertension according to the 2017/ACC/AHA guide also fulfilled the criteria for prehypertension. Therefore, it is our expectation that many of the pathophysiological processes and clinical characteristics of prehypertension may now be applicable to the 2017/ACC/AHA stage 1 hypertension, which constitutes the majority of hypertensives in our sample. Prehypertension is characterized by autonomic and metabolic dysfunction (26) and has been correlated with the metabolic syndrome, dyslipidaemia, diabetes, obesity (27)/ increased BMI, high visceral adipose index, and increased heart rate (28). Autonomic dysfunction coexists with prehypertension and is closely related to changes in BP and lipid metabolism (26). Increased resting heart rate was associated with higher blood pressure, lower pulse pressure and increased risk of prehypertension and hypertension for males and females, and waist–height ratio, as a measure of abdominal obesity, further increased this association (29). Our results suggest that the autonomic and metabolic dysfunction observed with prehypertension may continue to manifest in the new stage 1 hypertension. Although prehypertension is considered one of the predictors of the development of hypertension (27), not all people with prehypertension progress to develop hypertension as defined by JNC7 (30). The current hypertension classification is based on shared cardiovascular outcomes rather than pathophysiology. Further studies on the associations if hypertension the new classification are warranted.

Hypertension in young Saudis

Studies from Saudi Arabia have shown a progressive build-up of risk factors for hypertension at an early age. The prevalence of hypertension risk factors among Saudi schoolchildren has reached epidemic levels due to the adoption of unhealthy lifestyle habits, particularly sedentary lifestyle and poor diet (31). It is estimated that 34.2% of Saudi schoolchildren have abnormal BMI (32). This figure increases to 48.4% mong university students (33), and further increases are expected with time (34). While many prior studies from Saudi Arabia have recommended focusing on the modifiable risk factors for hypertension as a preventive and therapeutic measure (15,31,33,35), this goal remains far from reach due to the huge gap between knowledge and attitudes and practices among young adults. Despite having good knowledge,
few young Saudis actually adopt healthy lifestyle measures to reduce their cardiovascular risk (33).

In their recommendations on the management of obesity, the Canadian hypertension guidelines advise approaching weight loss management in a multidisciplinary fashion that includes behavioural intervention in addition to dietary education and promotion of physical activity (8). Concentrated efforts in training on healthy habits should be initiated in early childhood to increase their efficacy (31), improve children’s development, and prevent adulthood disease and disability (36). Parental involvement improves both children’s and parents’ behaviours (37). Development of family-based prevention programmes for obesity in children is therefore important (38).

**Early detection of hypertension in young women**

With the evidence showing that lower BP values result in reduced mortality and morbidity (2), establishing the true prevalence of hypertension and its risk factors in the community, particularly among the young, becomes a necessity. This information is important for health care planning including early diagnosis, management and prevention campaigns, with the aim of reducing future hypertension and related complications (15). Women have a greater projected hypertension prevalence compared with men, particularly in the age groups 35–64 years (34), and had a greater risk for stroke compared with men. As hypertension is the most prevalent modifiable risk factor for stroke globally in both sexes (39), efforts should be made to reduce or halt the projected rise in hypertension, particularly among women.

The new diagnostic cut-offs represent a challenge to the health care system in Saudi Arabia considering that with the previous classification, 57.8% of hypertensive Saudis were undiagnosed, and only 45% of treated hypertensives had controlled BP (13). The additional hypertension cases based on the new classification will increase the disease prevalence and management burden on the health care system (4).

**Limitations**

Although the majority of the hypertensives in our study had stage 1 hypertension, and were young women, who are expected to have a low risk profile (6), these women will constitute a burden to the health care system as they will require education on nonpharmacological interventions and regular follow-up (1). Knowing the important predictors of hypertension in this subgroup will help focus the management efforts in a cost–effective manner.
Another limitation in our study is that the questionnaire lacked a question on whether or not the participants had their BP measured recently. In our study, 77.1% of the hypertensives had never been told they had high BP reading. This number is significant considering that these values would have fallen in the prehypertension readings according to the previous JNC classification. One possible explanation may be that these participants (or some of them) were never screened for hypertension.

Funding: This research was funded by the Cardiovascular Disease in Women Research Chair at Princess Nourah bint Abdulrahman University. (Grant No. CDW-2018-01).

Competing interests: None declared.

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