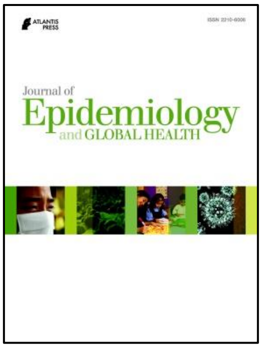

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Anthropometric risk factors and predictors of hypertension among Saudi adult population — A national survey

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Abstract This cross-sectional study aimed at determining the anthropometric predictors of hypertension among adults in Saudi Arabia. Multi-stage stratified sampling was used to select 4758 adult participants. The average of three blood pressure measurements using an automatic sphygmomanometer was considered the real blood pressure. Anthropometric measurements and socio-demographics were obtained from participants. The overall prevalence of hypertension was 25.5%. Hypertension was significantly positively associated with selected anthropometric measurements. Selected anthropometric measures were significant predictors of systolic and diastolic blood pressures except for hip measurements. Waist for height ratio was a significant predictor for isolated diastolic hypertension and combined systolic and diastolic hypertension. Waist circumference was the significant predictor for isolated systolic hypertension. Body mass index was a significant predictor for the combined systolic diastolic type. Waist for Hip Ratio was not a significant predictor for any of the hypertension subtypes.

Conclusion: Waist for height ratio is the most important predictor for blood pressure level and hypertension disease.

1. Introduction

1.1. Background

The Kingdom of Saudi Arabia (KSA) is considered one of the rapidly growing countries affected by lifestyle changes reflected by changes in disease patterns. Recent data have shown increasing rates

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of diseases, such as diabetes, hypertension and cardiovascular events [1,2]. The life expectancy has increased significantly and mortality has decreased, and the percentage of elderly population is increasing [1]. The burden of non-communicable diseases (NCDs) is rising rapidly and has now become a major challenge to both national and international development. The World Health Organization (WHO) recognizes this issue and has developed a global strategy for the prevention and control of NCDs [2]. Their strategy focuses on assessing the pattern and trends of risk factors of major NCDs. This will help in developing an evidence-based strategy to reduce unhealthy behaviors and major risk factors, and implementing cost-effective and equitable interventions [2]. Hypertension is an NCD that affects more than 25% of the global adult population, including KSA [3—5]. It is projected that by 2025, hypertension will increase by 24% to over 80% in developed and developing countries, respectively. This has the potential to overwhelm health care systems with increasing demands and related costs for treatment [5,6]. Obesity, on the other hand, affects about 25% to 30% of the adult population in KSA and is positively associated with the hypertension burden among adults [7]. The presence of both morbidities (obesity and hypertension) can adversely affect the health status of individuals and communities and has serious economic and social implications. High blood pressure (BP), which is indirectly identified through anthropometric indicators, may be an efficient strategy for the detection and control of obesity and hypertension, mainly because this approach can be implemented without specialized technical apparatus. A number of anthropometric measures, including body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR), are used as proxy measures for obesity. Many prospective and cross-sectional studies have used different anthropometric measures to understand the relationship between these measures and hypertension and its different subtypes, but they have been unable to resolve the issue [8—11]. To the best of our knowledge, no study in KSA has addressed this issue.

1.2. Study aims

The purpose of this study is to identify the anthropometric risk factors and predictors of BP (systolic [SBP] and diastolic [DBP]) levels and hypertension status.

2. Subjects and methods

This is a cross-sectional, community-based study that was implemented throughout the KSA in 2005. The WHO STEPwise approach to Surveillance (STEPS) of NCD risk factors was the basis for conducting the survey and for collecting the data [2,12].

2.1. Study population

Participants included the entire Saudi population from all 20 health regions of the country between the ages of 15 and 64. All Saudis less than 15 years of age and all non-Saudi subjects were excluded from participation in the study.

2.2. Sampling

A multistage stratified cluster random sampling technique was used to recruit the study subjects. Stratification was based on age (5 groups of 10 years each), gender (2 groups divided by gender), and health regions of the country (20 regions). Based upon the proposed methodology of the WHO STEPwise approach, a sample size of 196 was calculated for each of these 10 strata for a total of 5000 participants. A list of all primary health care centers (PHCCs) in each region was compiled, and 10% of these PHCCs were randomly chosen. Each center was allocated a regional sample proportionate to the size of their catchment population. A map of the health center coverage area was used to choose the households. Each house was assigned a number, and a simple random draw was made.

2.3. Data collection and data collectors

Data were collected using the WHO STEPwise approach, which includes a questionnaire, physical measurements, and biochemical measurements covering hypertension and other chronic diseases and risk factors. The questionnaire was translated into Arabic by a team of physicians and was then back translated to ensure the accuracy of translation. The Arabic instrument was pretested on 51 eligible respondents for wording and understanding of the questions, and any necessary adjustments and corrections were made. The questionnaire included socio-demographic data, history of BP, and BP measurements in addition to other chronic diseases and risk factors. Data were collected by 54 male and 54 female collectors who worked in teams. Each field team was made up of four individuals: a male data collector, a female data collector, a driver, and a female assistant. The data collection teams were supervised by a hierarchy of a local supervisor, a regional coordinator, and a national coordinator. All individuals involved in data collection attended a comprehensive training workshop that included interview techniques, data collection tools, practical applications, and field guidelines.

2.4. Blood pressure measurement

The measurements were taken using a digital sphygmomanometer. The respondent was advised to sit quietly and rest for 5 minutes with their legs uncrossed and their right arm free of clothing. Then, the right arm was placed on the table with the palm facing upwards. The appropriate cuff size was selected, and the artery position mark was aligned with the brachial artery. The cuff was wrapped snugly and fastened securely and was kept at the same level as the heart during measurement. Taking measurement involved the following steps: Pushing the START button began automatic inflation of the cuff and a display of the SBP and DBP readings, which were recorded. A second reading was taken 5 minutes after the first, and a third reading was taken 5 minutes after the second. The SBP was accepted as the first Korotkoff sound phase, and the DBP was accepted as the fifth phase (the disappearance of sounds) to the nearest 2 mmHg.

2.5. Definition of hypertension

The subjects were labeled hypertensive if the average of the three BP measurements was 140 mmHg or above for their SBP and/or 90 mmHg or above for their DBP or if the subject had been previously diagnosed with hypertension by a health professional. All of the participants with hypertension were further divided into three hypertension subtypes: isolated systolic hypertension (if their SBP was $\geqslant$140 mmHg and their DBP was <90 mmHg), isolated diastolic hypertension (if their DBP was $\geqslant$90 mmHg and their SBP was <140 mmHg), and combined hypertension (if their DBP was $\geqslant$90 mmHg and their SBP was $\geqslant$140 mmHg).

2.6. Anthropometric measurements

Body weight and height were measured without shoes using an electronic measuring scale. BMI was calculated as weight measured in kilograms (kg) to the nearest 0.1 kg divided by the height in meters squared (kg/m^2). WC was measured in centimeters midway between the lower costal margin and iliac crest during the end-expiratory phase. Hip circumference (HC) was measured in centimeters at the level of the greater trochanters. All measurements were recorded to the nearest centimeter. WHR was defined as the WC divided by the HC, while the WHtR ratio was defined as the WC divided by the height in centimeters. The cut-off levels for obesity were set according to WHO and U.S. standards [2,12,13]: BMI 30+, WHtR 0.5+, WHR 0.90+ for males and 0.85 for females excluding pregnant women, and WC 102+ cm for males and 88+ cm for females excluding pregnant women.

2.7. Data management and statistical analysis

Questionnaires collected from the field were reviewed by team leaders assigned to each team before submitting them to headquarters for data entry. Double entry of the questionnaires was performed using EPI-INFO 2000 software and EpiData software developed by the Menzes center for validation. After data entry, data cleaning was conducted. New variables were defined by adopting the standard Steps variables (STEPS Data Management Manual, Draft version v1.5, October 2003). Data analysis was conducted using SPSS (Version 17.0) software. The statistical analysis was performed using SPSS for Windows, version 17.0. The data were given as mean ± standard deviation for continuous variables and as counts and percentage for categorical variables. Association between categorical variables was assessed using a chi-square test. Logistic regression was used to investigate the associations of the binary dependent variable 'hypertension' with the independent 'obesity' anthropometric measurements variables. Multiple linear regression analysis was performed to identify significant predictors for the SBP and DBP levels. The level of significance was set at <0.05 throughout the study. The number of participants' responses used in the discrete statistical analyses varied due to missing data for certain variables.

2.8. Ethical clearance and confidentiality

The protocol and the instrument for the surveillance were approved by the Ministry of Health Centre of Biomedical Ethics and the concerned authorities in KSA. Informed consent of all subjects was obtained verbally and in written form. Confidentiality of data was assured, and all participants were informed that the data would only be used for the stated purpose of the survey. Further details of

Table 1 Age and gender distribution of hypertensive subjects *n* (%).

Characteristic *n* (%)	Hypertensives *n* (%)
Gender	
Males 2340 (49.2)	634 (27.1)
Females 2418 (50.8)	579 (23.9)
P value	0.013
Age (years)	
15—24 1076 (22.6)	95 (8.8)
25—34 1130 (23.8)	146 (12.9)
35—44 1167 (24.5)	304 (26.0)
45—55 841 (17.7)	355 (42.2)
55—64 544 (11.4)	313 (57.5)
P value	<0.001

the method used and sampling procedures can be found in STEPwise documents [2,12].

3. Results

Of the total expected 5000 participants, data from 4758 participants were analyzed for a response rate of about 95.2%. The rest (4.8%) were excluded because of major deficiencies in their data. Table 1 shows the age and gender distribution of the subjects and their hypertension status. Females comprised 50.8% of participants. Participants in age groups of 15—24, 25—34, and 35—44 comprised more than 20% of the participants for each age group. Elderly participants aged 55 years and above comprised 11.4% of the participants. Overall, 1213 subjects (25.5%) were hypertensives. There were significantly more males than females in the hypertensive group, and the presence of hypertension was found to increase significantly with age. Table 2 shows the distribution of the hypertension subtypes according to gender. All subtypes were significantly more common among males compared with females except for isolated systolic hypertension. Table 3 shows the prevalence of obesity according to the different anthropometric measurements used. Obesity prevalence ranged from 33.8%, as measured by WHtR, to 40.4%, as measured by WHR. Obesity was significantly higher in females than males except for obesity measured by WHR, which was significantly higher in males. Table 4 shows rates of hypertension according to the anthropometric measures of obesity. Overall hypertension, isolated systolic, and combined systolic diastolic hypertension types were significantly positively associated with all selected anthropometric measurements. The isolated diastolic subtype was only significantly positively associated with BMI and WHtR. Significant anthropometric measurements in bivariate analysis were entered in a logistic regression model for significant predictors of hypertension subtypes after controlling for age and gender. All selected anthropometric measurements were significant predictors for overall hypertension. Only WHtR was a significant predictor for isolated diastolic hypertension, while WC was the only predictor of isolated systolic hypertension. The WHR ratio was not a significant predictor for both the isolated and combined systolic diastolic types of hypertension, as can be seen in Table 5. Table 6 shows a linear regression analysis for significant anthropometric predictors of SBP and DBP levels. All selected anthropometric measurements were significant predictors of both SBP and DBP levels except WHR.

4. Discussion

Both hypertension and obesity are prevalent among adults in KSA, as shown in this study as well as a previous national study [7]. Efforts are needed to rapidly detect, prevent, control, and treat hypertension. Identifying risk factors and predictors is vital in this respect. The results of this study have revealed that almost all selected anthropometric measurements are significant risk factors and predictors for overall hypertension. For hypertension subtypes, WHtR predicted all subtypes except for isolated systolic, WC predicted the isolated and combined subtypes, BMI predicted only the combined subtype, and WHR did not predict SBP and

Table 2 Prevalence of hypertension subtypes according to sex of patients.

Variable	% hypertensive			
Gender	All hypertension	Combined systolic /diastolic	Isolated diastolic	Isolated systolic
Male	24.7	10.5	5.1	8.2
Female	18.6	7.6	2.9	7.5
Odds ratio (95% confidence interval)	1.44 (1.25—1.66)	1.43 (1.17—1.75)	1.90 (1.32—2.45)	1.10 (0.89—1.37)
P value	<0.001	0.001	<.001	0.200

Table 3 Prevalence of obesity using anthropometric measurements according to gender.

Obesity	Male *n* (%)	Female *n* (%)	Total *n* (%)	*P* value
Body mass index >_30	640 (28.6)	1017 (43.4)	1657 (36.1)	<0.001
Waist for Hip ratio Males >—0.9 Females >—0.85	1092 (48.2)	688 (32.1)	1780 (40.4)	<0.001
Waist circumference Males >—102 cm Females >—88 cm	602 (26.6)	912 (42.2)	1514 (34.2)	<0.001
Waist for height ratio >—0.5	718 (32.0)	764 (35.6)	1482 (33.8)	0.008

Table 4 Association of hypertension and its subtypes with anthropometric measurements of obesity.

Obesity indicator	All hypertensives	Isolated systolic	Isolated diastolic	Both systolic diastolic
Body mass index	*N* (%)	*N* (%)	*N* (%)	*N* (%)
Obese	596 (36.0)	165 (10.2)	78 (14.8)	206 (12.6)
Non obese	992 (20.2)	188 (6.5)	99 (3.4)	198 (6.8)
#OR (95% C.I.)	2.22 (1.94—2.54)	1.63 (1.31—2.03)	1.42 (1.05—1.92)	1.97 (1.61—2.42)
P value	<0.001	<0.001	0.016	<0.00
Waist circumference				
Obese	581 (38.4)	164 (11.1)	70 (4.7)	214 (14.3)
Non obese	601 (20.7)	185 (6.5)	107 (3.7)	193 (6.7)
#OR (95% C.I.)	2.39 (2.08—2.74)	1.79 (1.44—2.23)	1.27 (0.93—1.73)	2.32 (1.89—2.85)
P value	<0.001	<0.001	0.075	<0.001
Waist for Hip Ratio				
Obese	334 (34.5)	98 (10.3)	39 (4.1)	16 (12.1)
Non obese	848 (24.6)	251 (7.4)	138 (4.1)	291 (8.5)
#OR (95% C.I.)	1.62 (1.39—1.88)	1.43 (1.12—1.82)	1.01 (0.67—1.44)	1.47 (1.17—1.85)
P value	<0.001	0.003	0.527	0.001
Waist for height ratio				
Obese	922 (31.7)	252 (8.8)	135 (4.7)	337 (11.7)
Non obese	250 (16.9)	95 (6.5)	40 (2.7)	64 (4.4)
#OR (95% C.I.)	2.29 (1.96—2.68)	1.39 (1.09—1.77)	1.75 (1.23—2.51)	2.91 (2.21—3.83)
P value	<0.001	0.005	<0.001	<0.001

#OR(95% C.I.) = odds ratio (95% confidence interval).

DBP levels in linear regression analysis or any of the hypertension subtypes, as shown by the logistic regression analysis.

WHR was not found to be a significant risk factor and predictor of hypertension and BP levels, which is in agreement with many studies [14—17]. Other studies, however, found that WHR was significantly associated with hypertension and was considered to be an important predictor [18,19]. WHR does, however, offer additional information beyond BMI and WC to predict hypertension risk, and a 0.01 increase in WHR is associated with a 5% increase in risk [18,19]. Variations in these results may be noted due to differences in cut-off points, populations surveyed, and inter- and intra-observer's variations. Some studies have found that BMI is a significant predictor of hypertension, including a study in KSA among military personnel [20—22]. However, other studies do not agree [23]. BMI is the most common indicator used for obesity, but it does not reflect body fat distribution or distinguish between the accumulations of lean or fat mass. In addition, BMI is less sensitive to changes in lifestyle patterns than measures of abdominal obesity. Reduction of calorie intake and increased physical activity cause a reduction of body fat paralleled by an increase in muscle mass, resulting in marked changes in measures of abdominal obesity, but little to no change in BMI [24,25]. WC was found to be a significant predictor of both SBP

Table 5 Logistic regression analysis for anthropometric predictors of hypertension types.

Anthropometric indicator	All hypertensives	Isolated systolic	Isolated diastolic	Both systolic diastolic
Body mass index				
Odds ratio	1.58	1.30	1.31	1,30
95% confidence interval	1.34–1.86	0.99–1.70	0.91–1.89	1.10–1.67
P value	<0.001	0.063	0.150	0.039
Waist circumference				
Odds ratio	1.42	1.52	0.85	1.41
95% confidence interval	1.18–1.71	1.11–2.08	0.56–1.27	1.07–1.85
P value	<0.001	0.009	0.412	0.016
Waist for Hip Ratio				
Odds ratio	1.24	1.21	0.93	1.10
95% confidence interval	1.05–1.47	0.93–1.58	0.63–1.36	0.86–1.41
P value	0.011	0.149	0.703	0.443
Waist for height ratio				
Odds ratio	1.52	0.94	1.76	2.10
95% confidence interval	1.26–1.83	0.70–1.28	1.17–2.63	1.54–2.87
P value	<0.001	0.712	0.006	<0.001

Table 6 Linear regression analysis for predictors of blood pressures.

Anthropometric predictor	Systolic blood pressure	Diastolic blood pressure
Body mass index		
Beta	0.074	0.045
P value	<0.001	0.011
Waist circumference		
Beta	0.088	0.088
P value	<0.001	<0.001
Waist for Hip Ratio		
Beta	0.014	0.019
P value	0.390	0.230
Waist for height ratio		
Beta	0.129	0.191
P value	<0.001	<0.001

and DBP levels and a significant predictor of all hypertension subtypes except isolated diastolic hypertension. This is in agreement with studies which showed an important relationship between WC and the probability of emerging cardiovascular events [26]. WHtR was found to be the most important predictor of BP level and hypertension in this study. This is in agreement with several studies. A systematic review and meta-analysis showed that WHtR was a better predictor for hypertension and CVD risk in both sexes in various nationalities and ethnic groups [27–30]. WHtR may be a more useful tool for global clinical screening with a weighted mean boundary value of 0.5, supporting the simple public health message: 'Keep your waist circumference to less than half your height' [31].

4.1. Implications for practice

As discussed above, many anthropometric measurements have been shown to be powerful predictors of hypertension in the populations studied. Anthropometric measurements provide an effective, simple, inexpensive, and non-invasive means for a first-level screening for hypertension. Such a simple screening tool for identifying those who are at risk of developing central obesity with its subsequent co-morbidities would allow action to be taken at a young age [32,33]. No specialized health professionals or technical apparatus is needed. This strategy allows subjects to be screened at all health care facilities, particularly in primary health care settings. It can also be implemented in educational, work, and recreational settings, which can increase the yield significantly. There is a growing common opinion that WC should be seen as a 'vital sign' and recorded in the same manner as weight and height in the medical chart of every patient [9]. Measurement of WC alone as a proxy of abdominal fat mass has been suggested as a simple clinical alternative to BMI for detecting adults with possible health risks due to obesity. While opportunistic screening should be initiated at the earliest moment possible among patients at health facilities, outreach services should also be implemented to ensure high coverage. It is recommended that WC should be measured for all visitors of primary health care centers in KSA and recorded just like other vital signs. Along with helping to detect obesity and obesity-related morbidities, such as hypertension, this will encourage people to watch their waist circumference regularly by themselves. They only need a tape measure and a very simple demonstration of the procedure. WC measurement is a requirement for measuring WHtR, which is the most important anthropometric predictor of hypertension and blood pressure levels as revealed by this study.

4.2. Study limitations

Cross-sectional studies are not powerful for studying predictors. Inter- and intra-observer's errors in anthropometric and BP measurements are expected. The cut-off points for obesity diagnosis are international and not KSA specific.

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