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Utility of Obesity Indicators for Predicting Hypertension among Older Persons in Limpopo Province, South Africa

Perpetua Modjadji [1,*], Mulalo Caroline Salane [1], Kebogile Elizabeth Mokwena [1], Tshimangadzo Selina Mudau [2] and Peter Modupi Mphekgwana [3]

[1] Department of Public Health, School of Health Care Sciences, Sefako Makgatho Health Sciences University, 1 Molotlegi Street, Ga-Rankuwa 0208, South Africa; mulalosalane023@gmail.com (M.C.S.); kebogile.mokwena@smu.ac.za (K.E.M.)
[2] Department of Nursing Science, School of Health Care Sciences, Sefako Makgatho Health Sciences University, 1 Molotlegi Street, Ga-Rankuwa 0208, South Africa; selina.mudau@smu.ac.za
[3] Research Administration and Development, University of Limpopo, Polokwane 0700, South Africa; peter.mphekgwana@ul.ac.za
* Correspondence: perpetua.modjadji@smu.ac.za; Tel.: +27-12-521-3664

Abstract: In view of the epidemic proportions of obesity in South Africa and its relationship to cardiometabolic diseases, such as hypertension, a cross sectional study was conducted to investigate the utility of obesity indicators for predicting hypertension among older persons ($\geq$60 years, n = 350) in the Limpopo Province of South Africa. The WHO STEPwise approach was used to collect data on demographic and lifestyle factors. Anthropometrics and blood pressure were measured according to the standard procedures. Receiver operating characteristic curves (ROC) were used to investigate and compare the ability of obesity indicators to predict overall hypertension and either increased systolic (SBP) or increased diastolic (DBP) blood pressure. The area under the ROC curve (AUC) was used to assess a certain indicator's potential to predict overall hypertension and either increased SBP or increased DBP. Multivariate logistic regression analysis was used to determine the relationship of hypertension with obesity indicators. The mean age of the participants was 69 years (±SD = 7), and hypertension (46%), general obesity (36%) and abdominal obesity (57%) were prevalent among older persons. The obesity indicator body mass index (BMI) (AUC = 0.603 (0.52; 0.69)) was the best predictor of hypertension in older men. Waist circumference (WC) (AUC = 0.640 (0.56; 0.72)) and waist-to-height ratio (WHtR) (AUC = 0.605 (0.52; 0.69)) were better predictors of hypertension than BMI and waist-to-hip ratio (WHR) in older women. After adjustment for risk factors, only WC (AOR = 1.22 (1.16; 1.79)) was significantly associated with hypertension in older women, proposing WC as a screening tool for the prediction of hypertension in South African older women.

Keywords: obesity indicators; hypertension; older persons; rural community; South Africa

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1. Introduction

Population aging occurs globally, and older persons will reach two billion by 2050 [1]. During aging, there is a decline in metabolism and health, which predispose to diseases like hypertension [2,3]. Hypertension is common among older persons, causing cardiovascular diseases, mostly heart attacks and strokes [4]. Furthermore, aging predisposes to obesity, one of the predictors of hypertension [5–7]. The presence of obesity might lead to life threatening health issues, such as hypertension, type 2 diabetes mellitus, etc. [8]. The burden of hypertension, has been emphasized as a public health issue [9–13], occurring simultaneously with communicable diseases [14–16]. Formerly, hypertension, among other non-communicable risk factors, has been reported to be dominant in wealthy people, although lately, it occurs among households that are poverty stricken and residing in rural settings, mainly because of the epidemiologic shift [17,18].

South Africa has recorded 4.1 million older persons in 2011, with the number expected to increase to over 15 million by 2030 [19]. Hypertension alone is the most common diagnosed vascular disease in the country, leading to attending primary care [20]. Additionally, the country is affected by obesity across the entire population and all age groups [21–24]. Rates of hypertension and obesity among older persons in South Africa are high [25,26]. The Human Sciences Research Council (HSRC) has reported a 70.6% age-standardized prevalence of hypertension among older persons [27]. Additionally, the high prevalence of obesity (49.8%) has been reported in older person. Using waist circumference (WC), abdominal obesity has been estimated at 29.6% among older men versus 66.6% among older women, as well as by waist-hip ratio (WHR; 29.6% vs. 71.2%), respectively. A high waist-to-height ratio (WHtR; 62.6%), reported in South Africa, predisposes to cardio metabolic risk and hypertension [21,26]. The link of obesity to hypertension is suggested through the renin-angiotensin system, in addition to other mechanisms such as the sympathetic nervous system. the amount of intra-abdominal and intra-vascular fat, etc. [8,28].

The relation between obesity and hypertension is apparent [7,26,28]; nonetheless, the degree of the relationship is still unclear [29]. The literature documents obesity indicators (i.e., BMI, WC, WHR and WHtR) as good predictors of hypertension [30,31], but discrepancies in terms of settings and race have been reported in addition to the definitions of obesity [32]. Peltzer et al. [26] have reported a high prevalence of hypertension (77.3%), associated with being overweight/obese (by BMI; 72.4%), among older persons (≥50 years) from the locality types (urban and rural) and population groups (including Blacks, Coloureds, Indians or Asians and Whites) in South Africa. However, despite older persons being at a high risk of hypertension [33], the data are limited on the relationship among older persons in the rural settings of South Africa.

In view of the epidemic proportions of obesity in South Africa and its association with the cardio-metabolic diseases of hypertension, diabetes and dyslipidaemia, it is important to accurately identify obese individuals at increased risk for these conditions [21]. Therefore, the study investigated the utility of obesity indicators for predicting hypertension among older persons in a rural community, the Vhembe district of the Limpopo Province, South Africa. This study highlights the importance of community-based screening and more health research on hypertension among older persons in rural communities. This is because older persons are extremely affected by hypertension, and they have different health needs as they age [34].

2. Materials and Methods

2.1. Study Design and Setting

A cross-sectional study was conducted in the Vhembe District of the Limpopo Province, South Africa. The Vhembe District municipality is one of five districts in the Limpopo Province, the northern part of the country, and shares its border with Zimbabwe [35]. In terms of population size, in 2019, the Vhembe District had a total of 1,402,779 people, made up of four local municipalities; Thulamela, Makhado, Collins Chabane and Musina. Ninety-nine percent (99%) of the population are Black Africans [36].

2.2. Sample Size, Sampling Technique and Population

The study population consisted of older black persons aged 60 years and above. Purposive sampling was used to select the Thulamela local municipality because it is the most populated municipality (±497,237) in the Vhembe District, made up of 40 wards (i.e., geopolitical subdivisions of municipalities used for electoral purposes) with clustered areas [36]. According to Cooperative Governance and Traditional Affairs (COGTA) 2020 [36], older persons (≥60 years) in Thulamela made up 6% of the total population, which was estimated at ~29,800. Rao software calculator [37] was used to calculate a sample size, taking into consideration a 5% margin of error, 50% response distribution and between 90% CI and 95% CI. The sample size was estimated between 269 and 380.

A random sampling was used to select a significant number of main areas (six, in this case) in the Thulamela local municipality, followed by a systematic sampling used to select older persons by households and recruited through house visits. During house visits, every fifth house was considered in the selected sections of the communities. Initially, 501 households were selected, and, from each house, one elderly person participated in the study. However, at the end of data collection, 360 participated in the study, making the response rate in the study 87%, which is considered good [38]. The 501 households that were initially selected did not include the houses that did not have elderly people and the houses that had elderly people who were critically ill. Some houses were empty, as is the case in most rural areas, due to most of the children and grandchildren of elderly people taking them to their houses in the cities, as was explained by the neighbors during recruitment. Most of the older Black South Africans continue to live in extended household structures with children, grandchildren and other kin [39]. Rural areas are sparsely populated because many people leave rural areas and settle in the urban areas for more facilities. This society has homogeneity in terms of culture and socioeconomic status [40]. A sample of 360 was obtained; however, during data analysis, 10 questionnaires had missing information of over 10%, which included important variables such as SBP, DBP and weight values.

2.3. Data Collection and Tool

The data were collected by trained research assistants between August 2019 and December 2019, using a modified WHO STEPwise questionnaire, which included demographic information (personal and household), lifestyle factors (tobacco and alcohol use) and physical measurements (anthropometry and blood pressure) [41] (see supplementary file). For quality assurance, the questionnaire was validated through content and face validity, independent translators, a pilot study and the training of research assistants [42]. Three readings were conducted for both systolic (SBP) and diastolic (DBP) blood pressure using an Elite 1219 Blood Pressure Monitor (Shanghai International Holding Corp. GmbH (Hamburg, Germany), adhering to standard procedure [43]. The average of the last two readings was used as a participant's blood pressure [44], hypertension was defined at SBP $\geq$ 140 mmHg and/or DBP $\geq$ 90 mmHg for hypertension [18], high SBP was $\geq$140 mmHg and high SBP was $\geq$90 mmHg. Weight, height, and waist and hip circumferences were measured according to the WHO recommendations [45] using a smart D-quip electronic scale, stadiometer and non-stretchable tape measure, respectively, and to the nearest 0.1 kg, 0.1 cm and 0.1 cm, respectively. BMI was calculated by dividing an individual's weight in kilograms (kg) by height in meters squared, and overweight was defined as BMI $\geq$ 25–29.9 kg/m^2 and obesity as BMI $\geq$ 30 kg/m^2, while abdominal obesity was indicated by WHtR of $\geq$0.5 [46], WC $\geq$ 90 cm and WHR > 0.90.

2.4. Data Analysis

STATA (Intercooled Stata® Version 14; StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX, USA) was used to analyze descriptive and inferential data. We used complete case analysis to identify the participants with missing data during analysis. Descriptive statistics were computed and the results are presented as means $\pm$ standard deviation (SD). A chi-squared test was used to compare variables by gender and blood pressure status, and the results are presented as frequency (n) and percentage (%). To investigate and compare the ability of obesity indicators to predict overall hypertension and either increased SBP or increased DBP, we used receiver operating characteristic curves (ROC). The area under the ROC curve (AUC) was used to assess a certain indicator's potential to predict overall hypertension and either increased SBP or increased DBP. The closer the AUC is to 1, the better the model, and the closer it is to 0.5, the poorer the model. Multivariate logistic regression analysis used dichotomous data to determine the relationship of hypertension with overweight/obesity indicators by gender and adjusted odds ratios (AOR) for age, smoking, alcohol, marital status, education, old age grant and family history of hypertension. The study adjusted for confounders by entering them as covariates in the model. A probability of $p < 0.05$ was considered significant.

2.5. Ethical Considerations

The study was approved by the Sefako Makgatho Health Sciences University Research and Ethics Committee [SMUREC/H/25/2019:PG] and adhered to the guidelines laid down in the Declaration of Helsinki [47]. Participants gave written consent prior to participating in the study.

3. Results

3.1. The Demographic Characteristics of Participants

Table 1 shows a comparison of the characteristics of participants by gender. Out of 350 participants, 165 (46%) were men and 185 (53%) were women. The mean age of the participants was 69 years (±SD = 7). Most participants were or had been married (97%), while 69% had a low literacy level. The majority of participants lived in brick houses (85%), had electricity (97%) and access to municipal water (100%) but used pit toilets (87%). Significant differences in proportions were observed for level of education ($p = 0.002$), household headship ($p \leq 0.0001$), household income ($p = 0.015$), alcohol use ($p = 0.001$) and family history of hypertension ($p = 0.024$) between men and women.

Table 1. Comparison of the characteristics of participants by gender.

Variables	All, *n* = 350 *n* (%)	Men, *n* = 165 *n* (%)	Women, *n* = 185 *n* (%)	*p*-Value
Age (years)				
Mean	69 (±SD = 7)	70 (±SD = 7)	68 (±SD = 7)	0.017 *
<69	184 (53)	79 (47)	105 (57)	0.097
≥69	166 (47)	86 (52)	80 (43)	
Marital status				
Ever married	341 (97)	158 (96)	183 (99)	0.062
Single	9 (3)	7 (4)	2 (1)	
Level of education				
Low literacy	240 (69)	100 (61)	140 (76)	0.002 *
High literacy	110 (31)	65 (39)	45 (24)	
Receiving old age grant				
No	13 (4)	3 (2)	10 (5)	0.093
Yes	337 (96)	162 (98)	175 (95)	
Employed				
No	329 (94)	159 (96)	170 (92)	0.113
Yes	21 (6)	6 (4)	15 (8)	
Household headship				
Self	224 (64)	131 (79)	93 (50)	
Spouse	71 (20)	8 (5)	63 (34)	≤0.0001 *
Child of the participant	51 (15)	24 (15)	27 (15)	
Relative	4 (1)	2 (1)	2 (1)	
Living with				
Alone	23 (7)	8 (5)	15 (8)	0.219
Family members	327 (93)	157 (95)	170 (91)	
Dwelling place				
Brick-house	301 (86)	143 (87)	158 (85)	0.734
Non-brick house	49 (14)	22 (13)	27 (15)	

Table 1. *Cont.*

Variables	All, *n* = 350 *n* (%)	Men, *n* = 165 *n* (%)	Women, *n* = 185 *n* (%)	*p*-Value
Household income				
<R5000 (<$323.31)	127 (36)	49 (30)	78 (42)	0.015 *
≥R5000 (≥$323.31)	223 (64)	116 (70)	107 (58)	
Access to electricity				
No	0 (0)	0	0	1.000
Yes	350 (100)	165 (100)	185 (0)	
Access to water				
No	0 (0)	0	0	1.000
Yes	350 (100)	165 (100)	185 (0)	
Type of toilet				
Flush	8 (2)	4 (2)	4 (2)	1.000
Pit	242 (98)	161 (98)	161 (98)	
Smoking				
No	194 (55)	83 (50)	111(60)	0.068
Yes	156 (45)	82 (50)	74 (40)	
Alcohol use				
No	225 (64)	91 (55)	134 (72)	0.001 *
Yes	125 (36)	74 (45)	51 (28)	
Family history of hypertension				0.024 *
No	279 (80)	140 (85)	139 (75)	
Yes	71 (20)	25 (15)	46 (25)	

n stands for frequency, % stands for percentage, * indicates significant differences, low literacy means participants did not attend secondary school and attended up to primary school, high literacy means participants attained secondary school education or post, non-brick houses are those made of mud and zinc.

3.2. Anthropometric Characteristics of Older Persons

In Table 2, the blood pressure and weight statuses of the participants are compared by gender. The overall prevalence of hypertension, overweight and obesity were 45%, 46% and 36%, respectively. Significant differences in proportions for BMI ($p \leq 0.0001$), WC ($p \leq 0.0001$) and WHtR ($p = 0.039$) were observed between older men and women. Abdominal obesity by WC was observed among 57% of the participants, with women being more affected (87%, $p \leq 0.0001$) compared to men (23%).

Table 2. Comparison of blood pressure and weight statuses of participants by gender.

Variables	All, *n* = 350 *n* (%)	Men, *n* = 165 *n* (%)	Women, *n* = 185 *n* (%)	*p*-Value
Blood pressure (mmHg)				0.652
Normal	189 (54)	87 (53)	102 (55)	
High	161 (46)	78 (47)	83 (45)	
SBP (mmHg)				
Mean	135 (±SD = 21)	135 (±SD = 21)	135 (±SD = 22)	0.912
Normal	108 (242)	48 (29)	60 (32)	0.499
High	242 (69)	117 (71)	125 (68)	
DBP (mmHg)				
Mean	81 (±SD = 13)	82 (±SD = 11)	81 (±SD = 11)	0.588
Normal	178 (51)	82 (50)	96 (52)	0.682
High	172 (49)	83 (50)	89 (48)	

Table 2. *Cont.*

Variables	All, *n* = 350 *n* (%)	Men, *n* = 165 *n* (%)	Women, *n* = 185 *n* (%)	*p*-Value
BMI (kg/m^2)				
Mean	29 (±SD = 5)	28 (±SD = 4)	31 (±SD = 6)	
Underweight	2 (1)	2 (1)	0 (0)	≤0.0001 *
Normal	61 (17)	33 (20)	28 (15)	≤0.0001 *
Overweight	162 (46)	94 (57)	68 (37)	
Obese	125 (36)	36 (22)	89 (48)	
Waist (cm)				
Mean	91 (±SD = 12)	88 (±SD = 11)	93 (±SD = 13)	≤0.0001 *
Normal	151 (43)	127 (78)	24 (13)	≤0.0001 *
Abdominal obesity	199 (57)	38 (23)	161 (87)	
WHR				
Mean	0.95 (±SD = 0.01)	0.97 (±SD = 0.01)	0.92 (±SD = 0.07)	≤0.0001 *
Normal	41 (12)	18 (11)	23 (12)	0.658
Abdominal obesity	309 (88)	147 (89)	162 (88)	
WHtR				
Mean	0.58 (±SD = 0.08)	0.55 (±SD = 0.07)	0.60 (±SD = 0.09)	≤0.0001 *
Normal	7 (2)	6 (4)	1 (1)	0.039 *
Abdominal obesity	343 (98)	159 (96)	184 (99)	

n stands for frequency, % stands for percentage, * indicates significant differences. BMI stands for body mass index: normal (19 to 24.9 kg/m^2), underweight (<18.5 kg/m^2), overweight (25 to 29.9 kg/m^2), obesity (≥30 kg/m^2). WC stands for waist circumference: normal (<88 cm), abdominal obesity (≥94 cm for men and ≥80 cm for women). WHR stands for waist-hip ratio: normal (<0.85), abdominal obesity (>0.90 for men and >0.85 for women). WHtR stands for waist-to-height ratio: normal (<0.5), abdominal obesity (≥0.5).

Table 3 presents the comparison of anthropometric indices by blood pressure status. Significant differences in BMI and WC proportions were observed by blood pressure status among men and women.

Table 3. Comparison of anthropometric indices in men and women by blood pressure status.

Variables	Normotensive, *n* (%)			Hypertensive, *n* (%)		
	All *n* = 189	Male *n* = 87	Female *n* = 102	All *n* = 161	Male *n* = 78	Female *n* = 83
BMI (kg/m^2)						
Normal	37 (20) *	20 (23)	17 (17) *	24 (15) *	13 (17)	11 (13) *
Overweight	98 (52)	53 (61)	45 (44)	64 (40)	41 (52)	23 (28)
Obesity	52 (27)	12 (14)	40 (39)	73 (45)	24 (31)	49 (59)
Underweight	2 (1)	2 (2)	0	0	0	0
Waist (cm)						
Normal	91 (48) *	71 (82)	20 (20) *	60 (37) *	56 (72)	4 (5) *
Abdominal obesity	98 (52)	16 (18)	82 (80)	101 (63)	22 (28)	79 (95)
WHR						
Normal	19 (10)	6 (10)	13 (13)	22 (14)	12 (15)	10 (12)
Abdominal obesity	170 (90)	81 (90)	89 (87)	139 (86)	66 (85)	73 (88)
WHtR						
Normal	5 (3)	4 (5)	1 (1)	2 (1)	2 (3)	0 (0)
Abdominal obesity	184 (97)	83 (95)	101 (99)	159 (99)	76 (97)	83 (100)

n stands for frequency, % stands for percentage, * indicates significant difference ($p < 0.05$) between normotensive and hypertensive groups.

In Figure 1, ROC analyses for elevated SBP among men showed that the WC (AUC = 0.69, $p = 0.001$), WHtR (AUC = 0.66, $p = 0.001$) and BMI (AUC = 0.64, $p = 0.002$) were the largest and most significant as compared to WHR (AUC = 0.46, $p = 0.363$). On the other hand, no significant predictor was observed among men for elevated DBP with obesity indicators (WC, WHtR, WHR and BMI), Figure 2.

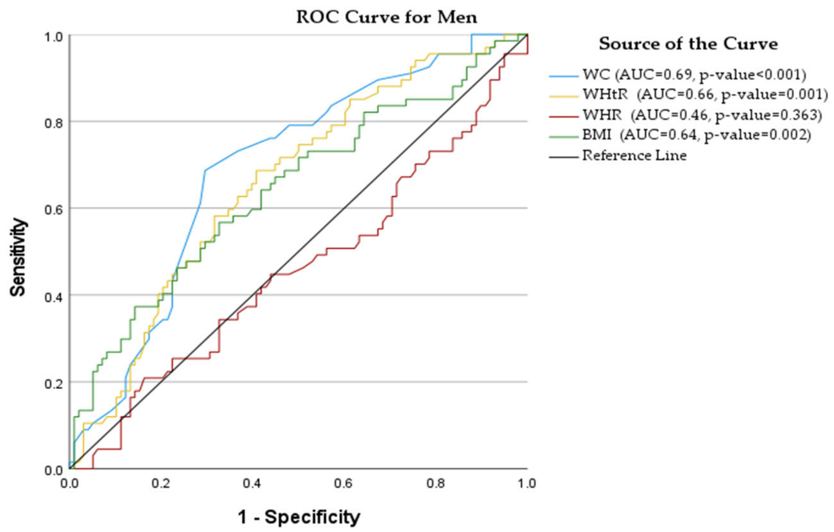

Figure 1. ROC curves for men presenting the relationship between obesity indicators and elevated SBP (≥140 mmHg).

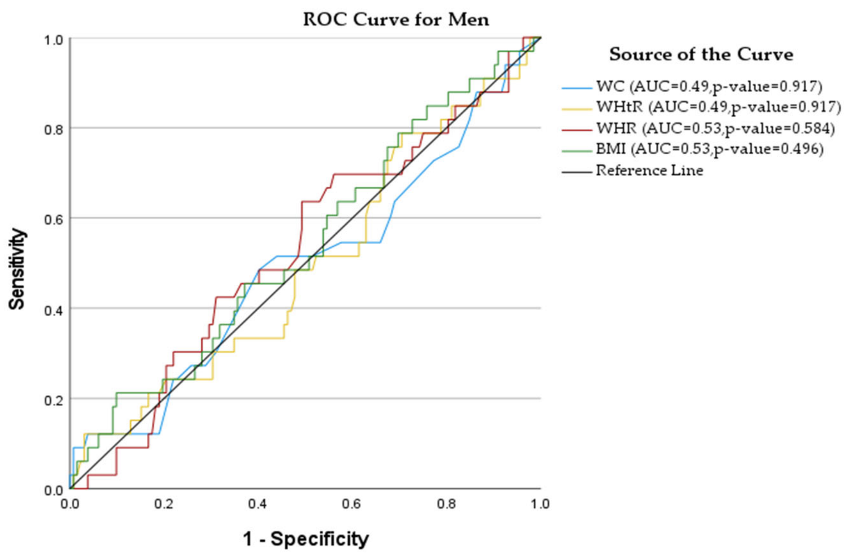

Figure 2. ROC curves for men presenting the relationship between obesity indicators and elevated DBP (≥90 mmHg).

Figures 3 and 4 demonstrate that the WC and WHtR were the greatest and most significant predictors of elevated SBP and DBP in women. BMI, on the other hand, was found to be a significant predictor of elevated DBP rather than SBP in women. Furthermore, it was also found that WHR was a poor predictor of SBP and DBP in older women.

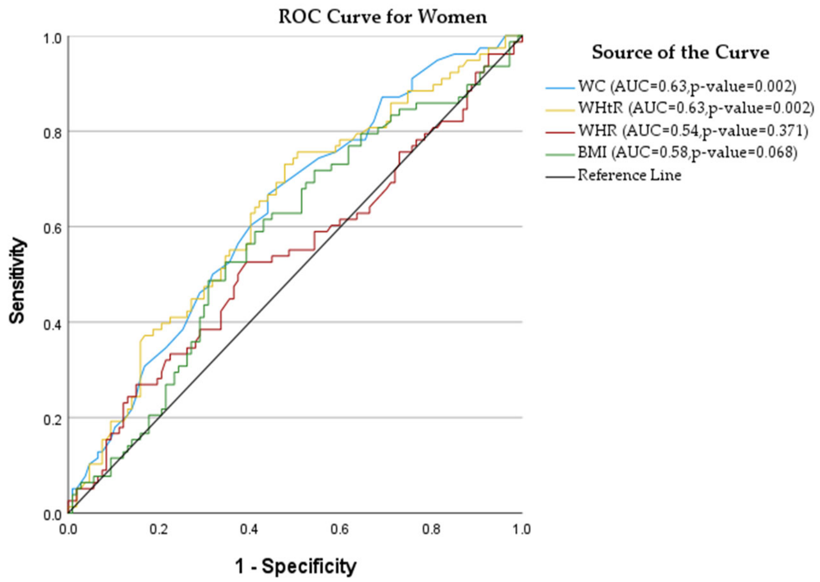

Figure 3. ROC curves for women presenting the relationship between obesity indicators and elevated SBP (≥140 mmHg).

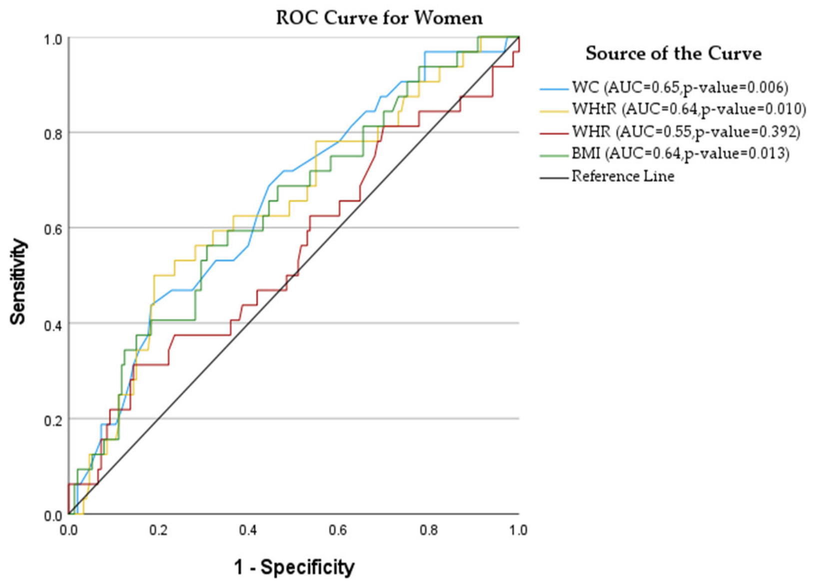

Figure 4. ROC curves for women presenting the relationship between obesity indicators and elevated DBP (≥90 mmHg).

Table 4 shows ROC analyses for hypertension among older men and women. It was observed that BMI had the highest significant AUC value for men. The BMI AUC differs significantly from 0.5 (*p*-value = 0.026), indicating that BMI was likely to be a better predictor of hypertension for men. The cut-off value in men was 27.5 for BMI. Among women, WHtR and WC were found to be significant predictors to hypertension, with AUC values of 60% and 64%, respectively. The cut-off value in women was 0.58 and 90.50 for WHtR and WC, respectively. It was observed that the AUC value of WC was greater than WHtR (Table 4). WHR was not a significant predictor of hypertension in both sexes. The WHtR and WC in men were non-significant predictors of hypertension.

Table 4. The area under the ROC curve (AUC) to predict hypertension among men and women.

Anthropometric Index	AUC (95% CI)	Cut-Off Point	Sensitivity (%)	Specificity (%)	*p*-Value
Men					
BMI	0.603 (0.52; 0.69) *	27.50	61	57	0.026
WHR	0.505 (0.41; 0.60)	0.96	55	47	0.914
WHtR	0.589 (0.50; 0.68)	0.55	55	61	0.053
WC	0.582 (0.49; 0.67)	87.50	62	55	0.077
Women					
BMI	0.554 (0.47; 0.64)	29.04	62	53	0.208
WHR	0.497 (0.41; 0.58)	0.90	50	43	0.954
WHtR	0.605 (0.52; 0.69) *	0.58	61	55	0.014
WC	0.640 (0.56; 0.72) *	90.50	67	57	0.001

* Significant difference ($p < 0.05$).

Table 5 shows the analysis of multivariate logistic regression for adjusted odds ratio (AOR) for the association of obesity indicators and hypertension. The results for unadjusted Model 1 showed non-significant anthropometric indices for men in women. After adjusting for age and smoking and alcohol use (Model 2 and Model 3), non-significant anthropometric indices in both sexes were also observed. In Model 4, after adjusting for covariates (age, smoking and alcohol use, marital status, education, old age grant and family history of hypertension), only WC (AOR = 1.22 (1.16; 1.79)) in women was found to be significantly associated with hypertension.

Table 5. Association of obesity indicators with hypertension.

Variable	Model 1 AOR (95% CI)	Model 2 AOR (95% CI)	Model 3 AOR (95% CI)	Model 4 AOR (95% CI)
Men				
BMI ($\geq$25 kg/m^2)	1.84 (0.78; 4.62)	1.77 (0.74; 4.51)	1.78 (0.74; 4.55)	1.57 (0.61; 4.30)
WHR ($\geq$0.90)	0.51 (0.18; 1.42)	0.49 (0.16; 1.40)	0.49 (0.16; 1.42)	0.43 (0.13; 1.38)
WHtR ($\geq$0.50)	1.58 (0.73; 3.42)	1.62 (0.74; 3.53)	1.62 (0.74; 3.53)	1.20 (0.49; 2.88)
WC ($\geq$90 cm)	0.86 (0.35; 2.10)	0.85 (0.34; 2.10)	0.84 (0.34; 2.09)	0.58 (0.19; 1.66)
Women				
BMI ($\geq$25 kg/m^2)	0.99 (0.42; 2.40)	1.04 (0.43; 2.57)	1.01 (0.41; 2.50)	1.17 (0.42; 3.37)
WHR ($\geq$0.90)	0.90 (0.36; 2.27)	0.79 (0.31; 2.04)	0.78 (0.30; 2.01)	1.01 (0.33; 3.28)
WHtR ($\geq$0.50)	1.11 (0.51; 2.45)	1.11 (0.50; 2.46)	1.11 (0.51; 2.48)	0.83 (0.34; 2.03)
WC ($\geq$90 cm)	2.99 (0.94; 10.75)	2.93 (0.92; 10.55)	2.86 (0.89; 10.34)	1.22 (1.16; 1.79) *

* Significant difference ($p < 0.05$). Model 1: BMI, WHR, WHtR, WC; Model 2: BMI, WHR, WHtR, WC, age; Model 3: BMI, WHR, WHtR, WC, age, smoking, alcohol; Model 4: BMI, WHR, WHtR, WC, age, smoking and alcohol use, marital status, education, old age grant, family history of hypertension.

4. Discussion

The main objective of this study was to investigate the utility of obesity indicators for predicting hypertension among older persons in the rural community of Limpopo Province, South Africa. The study determined the prevalence of general obesity, abdominal obesity and hypertension and, thereafter, the relationship between obesity indicators and hypertension. The area under the ROC curve (AUC) was used to assess a certain indicator's potential to predict overall hypertension and either increased SBP or increased DBP. Regarding the socio-demographic status, the current study reported a high level of low literacy and dependence on old age grants among the participants in the Vhembe District, similar to other reports in South Africa [36,48–50].

Generally, this study showed a 46% rate of hypertension among older persons. The reported prevalence of hypertension in this study is lower than the prevalence reported in South Africa (77.9%) among older persons [26,51] and in other LMICs, such as Ghana

(57.1%) and Mexico (58.2%). However, a lower prevalence of hypertension among older persons in comparison to the current study has been reported in countries like Zambia (34.8%) [52] and Ethiopia (41.9%) [17], while similar prevalence has been reported in Nepal (44.9%) [53] and in Brazil (46.7%) [54]. Researchers have suggested that the increased prevalence of hypertension among older persons might be due to endothelial function, which contributes significantly to increased arterial stiffness in patients with isolated systolic hypertension and increased age [55,56]. The present study also showed a higher prevalence of increased SBP (69%) than DBP (49%) among older persons. The literature documents that, until the age of 50 to 60 years, both SBP and DBP increase with age. Over the age of 60 years, in the majority of cases, SBP increases with age [57]. Elevated SBP is attributed to arterial stiffness as a major cause [57], and, among older persons, SBP is a superior marker of cardiovascular risk than DBP [58]. Although no significant difference in overall hypertension and increased SBP and DBP was observed between men and women in this study, the prevalence was slightly higher in men. The disproportion between genders in terms of hypertension prevalence that was observed in this study is consistent with several studies that report men to be more affected than women in developing countries [17,51,53,54].

Additionally, overweight/obesity (82%) and abdominal obesity (57%) were also high among older persons in this study. Obesity has been reported among older persons in South Africa (72.4%) [26], but the prevalence was high compared to studies in other African countries, e.g., Ghana (39.5%) [59] and Ethiopia (23.9%) [17], and lower in Malawi (21.9%) [60] and Nigeria (29.2%) [61]. Newman [62] reported that obesity among older persons is fuelled by several factors from social, environmental, genetic, etc. perspectives. There is a possibility that a diminishing energy expenditure, predominantly in older persons aged 50 to 65-years, interferes with body fat that increases with age. However, consequent fat accumulation among older persons aged ≥65 years could be attributed to hormonal changes accompanied by aging [62].

This study also showed a significant relationship between obesity indicators (WC, BMI and WHtR) and overall hypertension or either increased SBP or increased DBP in men and women, separately, and among older persons, collectively. Multivariate analysis showed that WC was significantly associated with hypertension after adjusting for marital status, education, old age grant and family history of hypertension. Generally, WC (64%) was a better predictor, followed by WHtR and BMI, with AUC around 60% in this study. Furthermore, most studies have reported a relationship between WC and hypertension among older persons [63,64], since WC may be a better indicator of total body fat rather than visceral fat [65]. WC is an indicator of abdominal obesity, linked to inflammation and contributing to the risk of CVD [66]. It is worth noting that BMI and WHtR [67] have been reported alongside WC as predictors of hypertension among both men and women in this study. Studies have reported that WHtR is more valued than BMI and WC in predicting hypertension [31,68,69]. While the risk of developing hypertension was greater with increased BMI compared to WC [70], other researchers suggest that visceral adiposity is generally a stronger predictor of hypertension than BMI-based measures [71]. Therefore, the current study showed that, with the exception of WHR, all other obesity indicators (WC, WHtR and BMI) are predictors of hypertensin in South African older persons.

Calderón-García et al. [72] have summarized that BMI does not differentiate between fat or lean mass, and it does not separate the location of central or peripheral fat; therefore, WC and WHR are the proposed indicators of abdominal obesity for their relation with fat distribution. On the other hand, WC is a limited indicator since it does not take an individual's height and weight into account, therefore overestimating and underestimating obesity among individuals who are either tall or short, respectively [72]. WHR has no benefit over WC alone, and it is infrequently used during the routine evaluation of obesity. On the other hand, a meta-analysis has shown that BMI, WC and BMI are similarly related to hypertension [72]. Furthermore, WHtR has been recommended as a determinant of metabolic and cardiovascular abnormalities since it is suggested to reduce limitations of

BMI, WC and WHR [72]. Therefore, the use of a combination of obesity indicators, especially WC, WHtR and BMI, in various population groups provides important information. This also highlights a need to revise the cut-points to identify cardiometabolic diseases in African populations.

The above substantiates our findings that WC and WHtR were significantly related to hypertension, with the AUC value of BMI approximately equivalent to that of WHtR. However, the results have not been consistent between men and women. The main contribution of our study is that it focuses on older persons, a research area that has been rarely addressed in South Africa, although the possible mechanisms of the association between measures of abdominal obesity and hypertension are consistently well established [8,28]. In the current study, we identified cut-off levels that may be applied to evaluate the risk of adverse outcomes. This is because the cut-off levels of anthropometric measures have been adapted from Caucasian or non-black African populations [73–75], influencing the variability of the predictive capabilities for cardiovascular risks in other populations.

5. Limitations of the Study

There were some limitations in this study. First, the onset of hypertension among older persons could not be determined because of the cross-sectional designed we used, which could only report on inferences. Second, the study was limited to rural communities; hence, it cannot be generalized to older persons living in different settings, except for rural settings with similar infrastructure and culture. Third, the use of 90% CI in sample calculation adds a large variation in the study and decreases power. As a result, the results of this study need to be duplicated, at the very least, in order to be more conclusive. A sample of 350 individuals marginally reaches adequacy for analysis. By using further stratification, the results can only be seen as preliminary findings based on inferences. Fourth, we could not include biochemical markers of hypertension and obesity among older persons due to budget constraints. Fifth, the current study did not assess other comorbidities (e.g., diabetes). Future studies should consider a comprehensive assessment of behavioural factors, dietary intake, biochemical variables and comorbidities to study hypertension and obesity among older persons. However, our study sheds a light on the prevalence of obesity indicators and hypertension and their relationship among older persons in the rural Vhembe District in South Africa.

6. Conclusions

This study demonstrates predominant general overweight/obesity, abdominal obesity and hypertension among rural older persons in the Vhembe District of Limpopo Province, South Africa. These findings clearly affirm the epidemiologic shift currently experienced by poor households in rural communities, which is suggestive of routine community-based screening for hypertension and obesity among older persons in rural populations. Close monitoring of older persons with identified risk factors should be emphasized to reinforce and implement preventive strategies to change the paradigm. Furthermore, ROC analyses showed that, with the exception of waist-to-hip (WHR), all other obesity indicators (WC, BMI and WHtR) could be used to predict hypertension among older persons, although at different degrees. Mostly, WC was significantly associated with hypertension in older women. Consequently, WC is proposed as a screening tool for the prediction of hypertension in South African older women. However, we further propose the incorporation of WC, BMI and WHtR routines into clinical practice instead of the over-reliance on BMI alone. Population-specific ranges or cut-off values are still serious issues to be revised to guide the implementation of lifestyle modifications in practice. Further corroboration in the context of our population is imperative.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/app12094697/s1. Questionnaire: Obesity indicators for predicting hypertension among South African older persons: A community-based study.

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References

1. Tabish, S.A. Population Aging Is a Global Phenomenon. 2012. Available online: https://www.researchgate.net/publication/262915215_Population_aging_is_a_global_phenomenon (accessed on 1 January 2022).
2. Lakatta, E.G.; Levy, D. Arterial and cardiac aging: Major shareholders in cardiovascular disease enterprises: Part I: Aging arteries: A “set up” for vascular disease. *Circulation* **2003**, *107*, 139–146. [CrossRef] [PubMed]
3. Jura, M.; Kozak, L.P. Obesity and related consequences to ageing. *Age* **2016**, *38*, 23. [CrossRef] [PubMed]
4. Baghel, D.S.; Kol, P.C.; Reddy, B. Oxidative Stress and Other Biochemical Parameters in Hypertension of Elderly males. *Biomed. Pharmacol. J.* **2014**, *7*, 247–251. [CrossRef]
5. Jensen, M.D. Role of body fat distribution and the metabolic complications of obesity. *J. Clin. Endocrinol. Metab.* **2008**, *93* (Suppl. 1), s57–s63. [CrossRef]
6. Sironi, A.M.; Gastaldelli, A.; Mari, A.; Ciociaro, D.; Postano, V.; Buzzigoli, E.; Ghione, S.; Turchi, S.; Lombardi, M.; Ferrannini, E. Visceral fat in hypertension: Influence on insulin resistance and β-cell function. *Hypertension* **2004**, *44*, 127–133. [CrossRef]
7. Bosy-Westphal, A.; Geisler, C.; Onur, S.; Korth, O.; Selberg, O.; Schrezenmeir, J.; Müller, M. Value of body fat mass vs anthropometric obesity indices in the assessment of metabolic risk factors. *Int. J. Obes.* **2006**, *30*, 475–483. [CrossRef]
8. Jiang, S.Z.; Lu, W.; Zong, X.F.; Ruan, H.Y.; Liu, Y. Obesity and hypertension. *Exp. Ther. Med.* **2016**, *12*, 2395–2399. [CrossRef]
9. Maimela, E.; Alberts, M.; Modjadji, S.E.; Choma, S.S.; Dikotope, S.A.; Ntuli, T.S.; Van Geertruyden, J.-P. The prevalence and determinants of chronic non-communicable disease risk factors amongst adults in the Dikgale health demographic and surveillance system (HDSS) site, Limpopo Province of South Africa. *PLoS ONE* **2016**, *11*, e0147926. [CrossRef]
10. Mphekgwana, P.M.; Malema, N.; Monyeki, K.D.; Mothiba, T.M.; Makgahlela, M.; Kgatla, N.; Makgato, I.; Sodi, T. Hypertension Prevalence and Determinants among Black South African Adults in Semi-Urban and Rural Areas. *Int. J. Environ. Res. Public Health* **2020**, *17*, 7463. [CrossRef]
11. Ntuli, S.T.; Maimela, E.; Alberts, M.; Choma, S.; Dikotope, S. Prevalence and associated risk factors of hypertension amongst adults in a rural community of Limpopo Province, South Africa. *Afr. J. Prim. Health Care Family Med.* **2015**, *7*, 1–5. [CrossRef]
12. Raphadu, T.T.; Staden, M.V.; Dibakwane, W.M.; Monyeki, K.D. A Non-Invasive Investigation into the Prevalence of Higher than Normal Blood Pressure, Hypertension and the Association between Blood Pressure and Body Weight in Male and Female Adolescents in the Polokwane Local Municipality, Limpopo-South Africa: A Cross-Sectional Study. *Children* **2020**, *7*, 18.
13. Bokaba, M.; Modjadji, P.; Mokwena, K.E. Undiagnosed Hypertension in a Workplace: The Case of a Logistics Company in Gauteng, South Africa. *Healthcare* **2021**, *9*, 964. [CrossRef]
14. Modjadji, P. Communicable and non-communicable diseases coexisting in South Africa. *Lancet Global Health* **2021**, *9*, e889–e890. [CrossRef]
15. Wong, E.B.; Olivier, S.; Gunda, R.; Koole, O.; Surujdeen, A.; Gareta, D.; Munatsi, D.; Modise, T.H.; Dreyer, J.; Nxumalo, S. Convergence of infectious and non-communicable disease epidemics in rural South Africa: A cross-sectional, population-based multimorbidity study. *Lancet Global Health* **2021**, *9*, e967–e976. [CrossRef]
16. Mahlangu, K.; Modjadji, P.; Madiba, S. The Nutritional Status of Adult Antiretroviral Therapy Recipients with a Recent HIV Diagnosis; A Cross-Sectional Study in Primary Health Facilities in Gauteng, South Africa. *Healthcare* **2020**, *8*, 290. [CrossRef]
17. Shukuri, A.; Tewelde, T.; Shaweno, T. Prevalence of old age hypertension and associated factors among older adults in rural Ethiopia. *Integr. Blood Press. Control* **2019**, *12*, 23. [CrossRef]

18. WHO. *Non Communicable Diseases Country Profiles*; World Health Organization: Geneva, Switzerland, 2011.
19. United Nations Department of Economic and Social Affairs PD: World Population Prospects: The 2015 Revision. United Nations Department of Economic and Social Affairs, Population Division 2015. Available online: https://esa.un.org/unpd/wpp/publications/files/key_findings_wpp_2015.pdf (accessed on 14 May 2020).
20. Mash, B.; Fairall, L.; Adejayan, O.; Ikpefan, O.; Kumari, J.; Mathee, S.; Okun, R.; Yogolelo, W. A morbidity survey of South African primary care. *PLoS ONE* **2012**, *7*, e32358. [CrossRef]
21. Peer, N.; Lombard, C.; Steyn, K.; Levitt, N. Waist-to-height ratio is a useful indicator of cardio-metabolic risk in South Africa. *Fam. Pract.* **2019**, *37*, 36–42. [CrossRef]
22. Debeila, S.; Modjadji, P.; Madiba, S. High prevalence of overall overweight/obesity and abdominal obesity amongst adolescents: An emerging nutritional problem in rural high schools in Limpopo Province, South Africa. *Afr. J. Prim. Health Care Family Med.* **2021**, *13*, e1–e9. [CrossRef]
23. Modjadji, P. Socio-demographic Determinants of Overweight and Obesity Among Mothers of Primary School Children Living in a Rural Health and Demographic Surveillance System Site, South Africa. *TOPHJ* **2020**, *13*, 518–528. [CrossRef]
24. Nkwana, M.R.; Monyeki, K.D.; Lebelo, S.L. Body Roundness Index, A Body Shape Index, Conicity Index, and Their Association with Nutritional Status and Cardiovascular Risk Factors in South African Rural Young Adults. *Int. J. Environ. Res. Public Health* **2021**, *18*, 281. [CrossRef]
25. Oldewage-Theron, W.H.; Egal, A.A.; Grobler, C.J. Is obesity associated with iron status in the elderly? A case study from Sharpeville, South Africa. *Public Health Nutr.* **2015**, *18*, 521–529. [CrossRef]
26. Peltzer, K.; Phaswana-Mafuya, N. Hypertension and associated factors in older adults in South Africa. *Cardiovasc. J. Afr.* **2013**, *24*, 66. [CrossRef]
27. Berry, K.M.; Parker, W.-A.; Mchiza, Z.J.; Sewpaul, R.; Labadarios, D.; Rosen, S.; Stokes, A. Quantifying unmet need for hypertension care in South Africa through a care cascade: Evidence from the SANHANES, 2011–2012. *BMJ Glob. Health* **2017**, *2*, e000348. [CrossRef]
28. DeMarco, V.G.; Aroor, A.R.; Sowers, J.R. The pathophysiology of hypertension in patients with obesity. *Nat. Rev. Endocrinol.* **2014**, *10*, 364–376. [CrossRef]
29. Lear, S.A.; Humphries, K.H.; Kohli, S.; Chockalingam, A.; Frohlich, J.J.; Birmingham, C.L. Visceral adipose tissue accumulation differs according to ethnic background: Results of the Multicultural Community Health Assessment Trial (M-CHAT). *Am. J. Clin. Nutr.* **2007**, *86*, 353–359. [CrossRef]
30. Nordstrand, N.; Gjevestad, E.; Dinh, K.; Hofsø, D.; Røislien, J.; Saltvedt, E.; Os, I.; Hjelmesæth, J. The relationship between various measures of obesity and arterial stiffness in morbidly obese patients. *BMC Cardiovasc. Disord.* **2011**, *11*, 7. [CrossRef]
31. Tawfik, H.M. Waist height ratio and waist circumference in relation to hypertension, Framingham risk score in hospitalized elderly Egyptians. *Egypt. Heart J.* **2018**, *70*, 213–216. [CrossRef]
32. Wang, S.-K.; Ma, W.; Wang, S.; Yi, X.-R.; Jia, H.-Y.; Xue, F. Obesity and its relationship with hypertension among adults 50 years and older in Jinan, China. *PLoS ONE* **2014**, *9*, e114424. [CrossRef] [PubMed]
33. Lin, Y.-A.; Chen, Y.-J.; Tsao, Y.-C.; Yeh, W.-C.; Li, W.-C.; Tzeng, I.S.; Chen, J.-Y. Relationship between obesity indices and hypertension among middle-aged and elderly populations in Taiwan: A community-based, cross-sectional study. *BMJ Open* **2019**, *9*, e031660. [CrossRef] [PubMed]
34. Addo, J.; Agyemang, C.; Smeeth, L.; Aikins, A.D.G.; Adusei, A.; Ogedegbe, O. A review of population-based studies on hypertension in Ghana. *Ghana Med. J.* **2012**, *46*, 4–11. [PubMed]
35. Muluvhu, T.C.; Monyeki, M.A.; Strydom, G.L.; Toriola, A.L. Relationship between obesity and blood pressure among employees in the Vhembe district municipality of Limpopo Province, South Africa: Cardiovascular topics. *Cardiovasc. J. Afr.* **2019**, *30*, 361–368. [CrossRef] [PubMed]
36. Cogta: Vhembe District Municipality, Limpopo Province. 2020. Available online: https://www.cogta.gov.za/ddm/wp-content/uploads/2020/11/Vhembe-October-2020.pdf (accessed on 20 October 2020).
37. Hightower, C.; Scott, K. Infer more, describe less: More powerful survey conclusions through easy inferential tests. *Issues Sci. Technol. Librariansh.* **2012**, 69. [CrossRef]
38. Fincham, J.E. Response rates and responsiveness for surveys, standards, and the Journal. *Am. J. Pharm. Educ.* **2008**, *72*, 43. [CrossRef]
39. Schatz, E.; Madhavan, S.; Collinson, M.; Gómez-Olivé, F.X.; Ralston, M. Dependent or Productive? A New Approach to Understanding the Social Positioning of Older South Africans through Living Arrangements. *Res. Aging* **2015**, *37*, 581–605. [CrossRef]
40. S F: Characteristics of Rural Settlements. 2019. Available online: https://rashidfaridi.com/2019/09/16/characteristics-of-rural-settlements/ (accessed on 25 February 2022).
41. Riley, L.; Guthold, R.; Cowan, M.; Savin, S.; Bhatti, L.; Armstrong, T.; Bonita, R. The World Health Organization STEPwise approach to noncommunicable disease risk-factor surveillance: Methods, challenges, and opportunities. *Am. J. Public Health* **2016**, *106*, 74–78. [CrossRef]
42. Tsang, S.; Royse, C.F.; Terkawi, A.S. Guidelines for developing, translating, and validating a questionnaire in perioperative and pain medicine. *Saudi J. Anaesth.* **2017**, *11* (Suppl. 1), S80–S89. [CrossRef]

43. Whelton, P.K.; Carey, R.M.; Aronow, W.S.; Casey, D.E.; Collins, K.J.; Himmelfarb, C.D.; DePalma, S.M.; Gidding, S.; Jamerson, K.A.; Jones, D.W. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: A report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *J. Am. Coll. Cardiol.* **2018**, *71*, e127–e248.
44. Pickering, T.; Miller, N.; Ogedegbe, G.; Krakoff, L.; Artinian, N.; Goff, D. American Society of Hypertension; Preventive Cardiovascular Nurses Association. Call to action on use and reimbursement for home blood pressure monitoring: A joint scientific statement from the American Heart Association, American Society of Hypertension, and Preventive Cardiovascular Nurses Association. *Hypertension* **2008**, *52*, 10–29.
45. WHO. *Physical Status: The Use and Interpretation of Anthropometry*; WHO Technical Report Series No. 854; Report of a WHO Expert Committee 1995; WHO: Geneva, Switzerland, 1995.
46. Ashwell, M.; Gibson, S. Waist-to-height ratio as an indicator of 'early health risk': Simpler and more predictive than using a 'matrix'based on BMI and waist circumference. *BMJ Open* **2016**, *6*, e010159. [CrossRef]
47. WMA: Declaration of Helsinki. Ethical Principles for Medical Research Involving Human Subjects. 2008. Available online: https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/doh-oct2008/ (accessed on 11 November 2018).
48. National Department of Health (NDoH). *S: South Africa Demographic and Health Survey 2016*; NDoH: Pretoria, South Africa; Rockville, MD, USA, 2019.
49. Modjadji, P.; Madiba, S. Childhood Undernutrition and Its Predictors in a Rural Health and Demographic Surveillance System Site in South Africa. *Int. J. Environ. Res. Public Health* **2019**, *16*, 3021. [CrossRef]
50. Ralston, M.; Schatz, E.; Menken, J.; Gómez-Olivé, F.X.; Tollman, S. Who benefits—Or does not—From South Africa's old age pension? Evidence from characteristics of rural pensioners and non-pensioners. *Int. J. Environ. Res. Public Health* **2016**, *13*, 85. [CrossRef]
51. Lloyd-Sherlock, P.; Beard, J.; Minicuci, N.; Ebrahim, S.; Chatterji, S. Hypertension among older adults in low-and middle-income countries: Prevalence, awareness and control. *Int. J. Epidemiol.* **2014**, *43*, 116–128. [CrossRef]
52. Goma, F.M.; Nzala, S.H.; Babaniyi, O.; Songolo, P.; Zyaambo, C.; Rudatsikira, E.; Siziya, S.; Muula, A.S. Prevalence of hypertension and its correlates in Lusaka urban district of Zambia: A population based survey. *Int. Arch. Med.* **2011**, *4*, 34. [CrossRef]
53. Manandhar, K.; Koju, R.; Sinha, N.; Humagain, S. Prevalence and associated risk factors of hypertension among people aged 50 years and more in Banepa Municipality, Nepal. *Kathmandu Univ. Med. J.* **2012**, *10*, 35–38. [CrossRef]
54. Mendes, T.d.A.B.; Goldbaum, M.; Segri, N.J.; Barros, M.B.d.A.; César, C.L.G.; Carandina, L. Factors associated with the prevalence of hypertension and control practices among elderly residents of São Paulo city, Brazil. *Cad. Saude Publica* **2013**, *29*, 2275–2286. [CrossRef]
55. Wallace, S.M.; Yasmin McEniery, C.M.; Mäki-Petäjä, K.M.; Booth, A.D.; Cockcroft, J.R.; Wilkinson, I.B. Isolated systolic hypertension is characterized by increased aortic stiffness and endothelial dysfunction. *Hypertension* **2007**, *50*, 228–233. [CrossRef]
56. Lionakis, N.; Mendrinos, D.; Sanidas, E.; Favatas, G.; Georgopoulou, M. Hypertension in the elderly. *World J. Cardiol.* **2012**, *4*, 135. [CrossRef]
57. Safar, M.E.; Levy, B.I.; Struijker-Boudier, H. Current perspectives on arterial stiffness and pulse pressure in hypertension and cardiovascular diseases. *Circulation* **2003**, *107*, 2864–2869. [CrossRef]
58. Franklin, S.S.; Gustin, W.T.; Wong, N.D.; Larson, M.G.; Weber, M.A.; Kannel, W.B.; Levy, D. Hemodynamic patterns of age-related changes in blood pressure. The Framingham Heart Study. *Circulation* **1997**, *96*, 308–315. [CrossRef]
59. Lartey, S.T.; Magnussen, C.G.; Si, L.; Boateng, G.O.; De Graaff, B.; Biritwum, R.B.; Minicuc, N.; Kowal, P.; Blizzard, L.; Palmer, A.J. Rapidly increasing prevalence of overweight and obesity in older Ghanaian adults from 2007–2015: Evidence from WHO-SAGE Waves 1 & 2. *PLoS ONE* **2019**, *14*, e0215045.
60. Msyamboza, K.P.; Kathyola, D.; Dzowela, T. Anthropometric measurements and prevalence of underweight, overweight and obesity in adult Malawians: Nationwide population based NCD STEPS survey. *Pan. Afr. Med. J.* **2013**, *15*, 108. [CrossRef]
61. Adebayo, R.A.; Balogun, M.O.; Adedoyin, R.A.; Obashoro-John, O.A.; Bisiriyu, L.A.; Abiodun, O.O. Prevalence and pattern of overweight and obesity in three rural communities in southwest Nigeria. *Diabetes Metab. Syndr. Obes. Targets Ther.* **2014**, *7*, 153. [CrossRef]
62. Newman, A. Obesity in older adults. *Online J. Issues Nurs.* **2009**, *14*, 1–8. [CrossRef]
63. Luz, R.H.; Barbosa, A.R.; d'Orsi, E. Waist circumference, body mass index and waist-height ratio: Are two indices better than one for identifying hypertension risk in older adults? *Prev. Med.* **2016**, *93*, 76–81. [CrossRef]
64. Zhang, W.; He, K.; Zhao, H.; Hu, X.; Yin, C.; Zhao, X.; Shi, S. Association of body mass index and waist circumference with high blood pressure in older adults. *BMC Geriatr.* **2021**, *21*, 260. [CrossRef]
65. Harris, T.B.; Visser, M.; Everhart, J.; Cauley, J.; Tylavsky, F.; Fuerst, T.; Zamboni, M.; Taaffe, D.; Resnick, H.E.; Scherzinger, A.; et al. Waist circumference and sagittal diameter reflect total body fat better than visceral fat in older men and women. The Health, Aging and Body Composition Study. *Ann. N. Y. Acad. Sci.* **2000**, *904*, 462–473. [CrossRef]
66. Berg, A.H.; Scherer, P.E. Adipose tissue, inflammation, and cardiovascular disease. *Circ. Res.* **2005**, *96*, 939–949. [CrossRef]
67. Sebati, B.; Monyeki, K.; Kemper, H.; Sekgala, M.; Mphekgwana, M. Anthropometric indices for predicting cardiovascular risk factors: Ellisras longitudinal study. *Am. J. Hum. Biol.* **2019**, *31*, e23293. [CrossRef]
68. Choi, J.R.; Koh, S.B.; Choi, E. Waist-to-height ratio index for predicting incidences of hypertension: The ARIRANG study. *BMC Public Health* **2018**, *18*, 767. [CrossRef]

69. Minh, Q.N.; Vo, M.H. Anthropometric Indexes for Predicting High Blood Pressure in Vietnamese Adults: A Cross-Sectional Study. *Integr. Blood Press Control.* **2020**, *13*, 181–186. [CrossRef] [PubMed]
70. Ghosh, J.; Bandyopadhyay, A. Comparative evaluation of obesity measures: Relationship with blood pressures and hypertension. *Singap. Med. J.* **2007**, *48*, 232.
71. Hirani, V.; Zaninotto, P.; Primatesta, P. Generalised and abdominal obesity and risk of diabetes, hypertension and hypertension–diabetes co-morbidity in England. *Public Health Nutr.* **2008**, *11*, 521–527. [CrossRef] [PubMed]
72. Calderón-García, J.F.; Roncero-Martín, R.; Rico-Martín, S.; De Nicolás-Jiménez, J.M.; López-Espuela, F.; Santano-Mogena, E.; Alfageme-García, P.; Sánchez Muñoz-Torrero, J.F. Effectiveness of Body Roundness Index (BRI) and a Body Shape Index (ABSI) in Predicting Hypertension: A Systematic Review and Meta-Analysis of Observational Studies. *Int. J. Environ. Res. Public Health* **2021**, *18*, 11607. [CrossRef]
73. World Health Organization. *ROfENUIZyciZy: Measuring Obesity: Classification and Description of Anthropometric Data: Report on a WHO Consultation on the Epidemiology of Obesity, Warsaw, 21–23 October 1987*; World Health Organization, Regional Office for Europe: Geneva, Switzerland; Copenhagen, Denmark, 1989.
74. Alberti, K.G.; Eckel, R.H.; Grundy, S.M.; Zimmet, P.Z.; Cleeman, J.I.; Donato, K.A.; Fruchart, J.C.; James, W.P.; Loria, C.M.; Smith, S.C., Jr. Harmonizing the metabolic syndrome: A joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. *Circulation* **2009**, *120*, 1640–1645.
75. Expert Panel on Detection, Evaluation. Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). *JAMA* **2001**, *285*, 2486–2497. [CrossRef]