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RESEARCH

Association between dietary adherence, anthropometric measurements and blood pressure in an urban black population, South Africa

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Objectives: The aim was to determine participants' dietary adherence by calculating a diet adherence score based on the Dietary Approaches to Stop Hypertension (DASH)-style diet; (2) to determine if there was an association between dietary adherence score, anthropometric measurements (waist circumference, body mass index (BMI), waist–hip ratio, waist-to-height-ratio) and blood pressure (BP) in a South African urban black population.
Design: Cross-sectional secondary analysis of data collected for the PURE study was undertaken.
Setting: Langa, the urban PURE study site in the Western Cape province, South Africa.
Subjects: The PURE study Western Cape urban cohort, 454 participants, aged 32–81 years was utilised.
Outcome measures: Dietary adherence scores were calculated and the BP and anthropometric measurements, respectively, of participants in the lowest and highest tertiles of dietary adherence scores were compared.
Results: Positive correlations were found between age, for both men and women, and systolic and diastolic BP. A significant positive correlation between added sugar intake and systolic blood pressure (SBP) was present only in the women. A significant positive correlation was found between BMI, diastolic BP and SBP in men only. No significant differences existed between BP of men or women in the lowest and top tertile groups according to dietary adherence score, but a significant inverse correlation between the dietary adherence score and SBP was found in women.
Conclusions: BMI was positively associated with BP in men, while dietary adherence score was negatively correlated with SBP in women.
Summary: Non-adherence to dietary guidelines presenting overconsumption of unhealthy foods may be associated with high blood pressure.

Keywords: blood pressure, body mass index, dietary adherence

Introduction

Chronic non-communicable diseases (CNCDs), which include cardiovascular disease, type 2 diabetes, certain cancers and respiratory diseases, will be responsible for 69% of all global deaths by 2030 with the greatest increases in low-income and middle-income countries.[1,2] Risk factors for CNCDs include alcohol and tobacco use, as well as an increased energy intake coupled with a decrease in physical activity.[1]

Guidelines such as the Dietary Approaches to Stop Hypertension (DASH) diet, Mediterranean diet and Dietary Guidelines for Americans have been proven to decrease risk for CNCDs when adhered to.[2,3] The South African Food-Based Dietary Guidelines (SAFBDG) were developed and first published in 2001 in an attempt to address malnutrition and diet-related diseases.[4] These guidelines, specifically developed for the South African population, were recently revised to include the latest scientific evidence and to address feedback received from users to reduce the risk of guidelines being misinterpreted.[5]

Over the years researchers have developed and used various indices such as the Healthy Eating Index (HEI), Alternate Healthy Eating Index (AHEI), the Mediterranean-style pattern (MedDietScore), alternate Mediterranean score (aMed) and the DASH score to measure dietary guideline adherence in subjects.[6] Compliance with food-based dietary guidelines, a Mediterranean and a DASH-style diet has also been shown to have a blood pressure lowering effect.[7,8] Participants who had lower blood pressure, waist circumference and body mass index tended to have higher dietary adherence scores.[8]

Various anthropometric measures such as body mass index (BMI), waist circumference (WC), waist-to-height ratio (WHtR) and waist–hip ratio (WHR) are used to identify persons at risk for CNCDs.[9] The World Health Organization (WHO) proposed cut-off points to categorise adults according to underweight, normal weight and obese categories.[9] Waist circumference, WHtR and WHR are used to determine central obesity, a known risk factor for CNCDs.[10,11] International recommendations propose two WC cut-off values, > 88 cm and > 102 cm, for substantially increased risk, for sub-Saharan African women and men respectively.[10,12] A WHtR < 0.5 has been associated with minimal risk for CNCDs,[11] while a WHR measurement ≥ 0.85 in women and 0.90 in men is indicative of central obesity.[10]

The purpose of this study was twofold: (1) to determine participants' adherence to dietary guidelines by calculating a dietary adherence score using an adapted version of the methodology developed by Fung and colleagues;[2] (2) to determine if there was an association between dietary adherence, anthropometric measurements (WC, BMI, WHtR, WHR) and blood pressure in a South African urban dwelling black population.

Methods

Study population and sampling

A cross-sectional secondary analysis of data collected for the Prospective Urban and Rural Epidemiological (PURE) study was performed. The PURE study aimed to recruit approximately 150 000 participants aged between 35 and 70 years living in more than 600 communities in 17 low-, middle- and high-income countries around the world. The participating countries' selection was based on representativeness of different socioeconomic status (SES). The study sites included are based on commitment of investigators to collecting good quality data over the planned 10-year period.[13] The University of the Western Cape's (UWC) School of Public Health (SoPH) collected data in Langa (urban community) in the Western Cape province and a rural community in the Eastern Cape province. Data obtained for 1 000 males and female participants recruited from the urban community site were available for this study. Dietary data were obtained for 968 participants by means of a quantified food frequency questionnaire. Physical activity data were available for 1 023 participants, and anthropometric measurements were available for 454 participants. Complete data were available for 454 participants, which equates to a 45% response rate. Three development areas in Langa mirror the socioeconomic status (SES) of residents. A street map obtained from the City of Cape Town was used to select streets randomly in each of the three areas; every second household was then approached for possible inclusion in the study.

Data collection

Data were collected during 2010. Demographic and smoking data were obtained by means of the PURE adult questionnaire during face-to-face interviews.[13] Trained fieldworkers also took participants' physical measurements (weight, height, waist and hip circumference, and blood pressure). Weight was measured to the nearest 0.1 kg, with subjects wearing minimal clothing, using a digital scale (UC-321 Precision scale, A&D Instruments, Oxford, UK). Height was measured using a stadiometer (3PHTROD, Detecto, Webb City, MO USA) with the participant standing with normal posture and barefoot. Measurements were read with the subjects' head in Frankfort plane to the nearest 0.1 cm. Body mass index was calculated by taking the weight (kg) and dividing it by the height (m) squared and presented by BMI category.[14] Waist circumference was measured over minimal clothing at the narrowest part of the body between the ribcage and iliac crest to the nearest 0.1 cm using a non-stretchable measuring tape (Dean, Cloth & Notions, London, UK).[14] Hip circumference was measured over minimal clothing at the widest part of the body over the buttocks, with the same measuring tape. Two readings for all anthropometric measurements were taken and the mean calculated.[14] Waist–hip ratio and WHtR were calculated. Blood pressure was measured on the left arm with the participant sitting relaxed, with the arm at heart level using a digital blood pressure monitor (Omron, Kyoto, Japan).[12]

Trained fieldworkers conducted the interviews with the participants and completed the quantified food frequency questionnaire, which was validated in this population.[15] Participants estimated portion sizes by using a food-portion photograph book and other suitable tools (MRC Dietary Assessment and Education Kit [DAEK]). Portion sizes were converted to weights by using standard tables[16] and nutrient and food intakes were calculated by using the South African food-composition database.[17] Food items were then divided into subgroups, namely dairy, fish, legumes, nuts and seeds, fruits and vegetables, fats and fibre. The dietary data were analysed using the MRC FoodFinder 3.0 software (http://mrc-foodfinder.software.informer.com/3.0/). A dietary adherence score was calculated based on nutrient and food group intakes as described under data analysis.[2]

Ethics approval

Ethical approval for the Western Cape PURE study was obtained from the Research and Higher Degrees committee from the University of the Western Cape (project number 13/3/5). Informed, written consent was obtained from each participant.

Data analysis

Due to the low response rate (45%), the age, quantitative food frequency questionnaire (QFFQ) data and physical activity data from the available 454 participants were compared with the same data of those for whom physical measurements were not taken, to determine bias introduced by missing data. Data analysis indicated no significant differences in the participants' characteristics (age, gender, education level and smoking status) between the study sample included for this paper, and the rest of the cohort which was excluded due to missing data. Most data deviated from the normal distribution. Therefore, medians and interquartile range were calculated for continuous demographic, anthropometric, dietary and blood pressure data of men and women. Percentage and frequencies were calculated for categorical data.

Dietary adherence scores were calculated by dividing food intakes into quintiles. Intakes of foods (dairy, fish, legumes, nuts and seeds, and fruit and vegetables), fats (monounsaturated fatty acids—MUFA, polyunsaturated fatty acids—PUFA, saturated fats) and fibre as recommended by the SAFBG[5] and DASH guidelines[2] were scored as follows: Q1 was allocated 1 point and quintile 5 equalled 5 points.[2] Thus participants who had intakes that fell into the lowest quintile had the lowest intakes of the recommended foods. Total fat, saturated fat, meat, added sugar, alcohol and sodium were categorised as foods that need to be consumed in limited amounts and were assigned a reverse score so that participants in Q1for these foods were assigned 5 points and those in Q5 were assigned 1 point. A maximum score of 65 points could thus be attained if participants consumed the identified foods as per the recommendations. Food group scores were then summed to calculate an overall score for each participant. A lower score indicated poorer dietary adherence. In addition, those whose adherence scores were in the first tertile group were classified as non-adherent. Those whose adherence scores were in the third tertile were classified as being adherent to the dietary guidelines.

Spearman correlations were calculated between continuous variables (dietary intake variables, anthropometric variables and BP) for men and women. Differences between anthropometric variables and BP of men and women were determined using the Mann–Whitney test. The Kruskal–Wallis test was used to compare the same variables across the three tertile groups of dietary adherence score. The presence of associations between dietary adherence vs. non-adherence and BMI (overweight/obese [$BMI \geq 25\ kg/m^2$] vs. normal weight [$BMI < 25\ kg/m^2$]),[14] WHtR (≤ 0.5 and > 0.5),[11] WHR (≤ 0.85 and ≥ 0.85 for females and ≤ 0.90 and ≥ 0.90 for males)[10] and WC (< 102 and ≥ 102 cm for males, < 88 cm and ≥ 88 cm for females)[10] were determined by means of chi-square tests.

Participants were classified as normotensive if their SBP was < 140 mmHg and their DBP was < 90 mmHg.[12] They were classified as hypertensive if their SBP was ≥ 140 mmHg or DBP was ≥ 90 mmHg, or if they were taking antihypertensive drugs.[12]

Logistic regression and odds ratios were used to determine associations between BP as the dependent variable (hypertensive vs. normotensive) and diet adherence score, age, smoking and physical activity as covariates. Data analysis was done using the Statistical Package for Social Studies (SPSS®) version 23 (SPSS Inc, Chicago, IL, USA).

Results

Demographic characteristics

Table 1 depicts the demographic profile of the participants. Approximately 67% ($n = 360$) of the participants had obtained secondary and 6% ($n = 19$) a tertiary education. The majority ($n = 338$; 74%) of the participants were unemployed. Almost 22% ($n = 84$) of the women and 20% ($n = 20$) of the men currently used alcohol. More than half (53%, $n = 237$) were moderately active.

Anthropometric measurements, dietary intakes and blood pressure of participants

The women had a significantly higher median weight, WC and BMI measurements than the men. A significant difference in WHR ($p = 0.001$), WHtR ($p = 0.0001$) and in DBP ($p = 0.013$) between the two groups was also found. The median dietary intakes from the different food groups were very similar for the men and women (Table 2).

Most (85.6%; $n = 292$) of the women were classified as overweight/obese in comparison to 45% ($n = 51$) of the men (Table 2). Almost 49% ($n = 172$) of the women and 53% ($n = 60$) of the men were classified as hypertensive (Table 1).

The dietary adherence scores assigned to the different food categories are depicted in Table 3. After the component score was computed the study sample had a total dietary adherence score that ranged from 21 to 58 out of a possible maximum of 65. Those whose adherence scores were in the first tertile group were classified as non-adherent. The upper cut-off point for the lower tertile group defined as non-adherent was a score of 31. Those whose adherence score was in the third tertile were classified as being adherent to the dietary guidelines, with a lower cut-off point score of 40.

Significant differences between sodium ($p = 0.001$), alcohol ($p = 0.006$), total energy ($p = 0.01$), saturated fat ($p = 0.001$), PUFA ($p = 0.079$), and MUFA intakes ($p = 0.005$) were present between tertile 1 and tertile 3 of the dietary adherence score groups. There were no differences in protein, fibre and carbohydrate intakes between tertile 1 and tertile 3 of the dietary adherence score groups. No significant differences were present between tertile groups for anthropometric measurements and blood pressure (Table 4).

A significant positive correlation was found between age and both DBP and SBP, in both men (0.422 and 0.312, respectively) and women (0.399 and 0.160, respectively). Significant negative correlations were found between dietary adherence score ($r = -0.108$), sodium intake ($r = -0.124$) and total energy intake ($r = -0.11$) and SBP in women only. A significant positive correlation was found between MUFA intake ($r = 0.154$) and added sugar ($r = 0.116$), respectively, and SBP for women only. Significant positive correlations were observed between WC, WHR and WHtR, and both SBP and DBP in the men, as well as DBP in the women (Table 5).

Logistic regression and odds ratios were used to determine associations between BP as the dependent variable (hypertensive vs. non-hypertensive) and dietary adherence score with age, current smoking, current alcohol use and physical activity as covariates. In the logistic regression model age only was significantly associated with being hypertensive. Those with the highest level of physical activity tended to have lower odds of being hypertensive (OR = 0.49, 95% CI, 0.22–1.07, $p = 0.07$). The dietary adherence score was not significantly associated with being hypertensive (OR = 0.97, 95% CI, 0.91–1.04, $p = 0.38$, Table 6).

Discussion

The main aim of this study was to assess whether diet quality as depicted by a dietary adherence score based on a combination of the DASH diet[2] and the SAFBDG[5] and anthropometric measurements was associated with blood pressure in an urban black population.

There was no significant difference in the distribution of the diet adherence scores between the men and women (Table 2). Participants with the lowest adherence scores had significantly lower intakes of dairy products, fruit and vegetables, legumes and fish, and higher intakes of meat and meat products and sodium in comparison with those in the highest diet adherence scores group. Intakes of total fat, SFA, MUFA and PUFA did not differ significantly between the lowest and highest adherence score groups.

A significant inverse association between the dietary adherence score and SBP in women was found. Studies support our finding that a low dietary adherence score (indicating an unhealthier dietary intake) was associated with higher blood pressure.[8]

Although sodium intake could not be quantified accurately in this study, participants categorised in the lowest tertile of dietary adherence scores had significantly higher sodium and saturated fat intakes than those in the top tertile of dietary adherence score. A high sodium intake has been associated with hypertension, a risk factor for cardiovascular disease.[16] Consequently a public health call by various health professionals and organisations for reducing salt consumption has been made.[18] This advisory for reduced salt intake is supported by the findings of a systematic review by Lala and colleagues,[19] which concluded that, even though they could not find a dose response link, a decrease in salt intake resulted in lower systolic and diastolic blood pressure.[19] Another unexpected finding was a weak, but significant negative correlation between sodium intake and SBP in the women. However, since we did not assess 24-hour urinary sodium excretion or added salt intakes, we did not have an accurate measure of dietary sodium intakes and cannot draw conclusions from this negative correlation.[20]

Saturated fat intake has been linked to SBP and DBP.[21] The DASH diet guidelines recommend a low saturated fat intake, which has been proven to reduce BP in a systematic review and meta-analysis.[22] Low intakes of PUFA have been associated with elevated blood pressure levels.[23] In our study, even though the majority of participants had PUFA intakes below the SAFBDG

Table 1: Sociodemographic, BMI and lifestyle profile of participants

Variable	Women *n* (%)	Men *n* (%)	Total *n* (%)	*p**
Gender	341 (75.1%)	113 (24.9%)	454	
Median age and interquartile range (years)	50.00 (45.2–57.5)	52 (41.5–58.0)		0.38
Marital status:				< 0.0001
Never married	184 (54)	45 (39.8)	229 (50.44)	
Currently married	94 (27.6)	43 (31.1)	137 (30.18)	
Common law/living with partner	10 (2.9)	8 (7.1)	18 (3.96)	
Widowed	35 (10.3)	6 (5.3)	41 (9.03)	
Separated	8 (2.3)	7 (6.2)	15 (3.3)	
Divorced	9 (2.6)	2 (1.80	11 (2.4)	
Missing	1 (0.3)	2 (1.8)	3 (0.7)	
Education level:				0.19
No school education	8 (2.3)	5 (4.4)	13 (2.86)	
Primary school	81 (23.8)	30 (26.5)	111 (24.4)	
High school/secondary school	238 (69.8)	68 (60.2)	306 (67.4)	
Trade school	1 (0.3)	2 (1.8)	3 (0.7)	
College/university	12 (3.5)	7 (6.2)	19 (6.4)	
Unknown	1 (0.3)	1 (0.9)	2 (0.4)	
Employment:				0.96
Currently employed	59 (18.4)	20 (17.7)	79 (17.4)	
Unemployed	253 (79.1)	85 (75.2)	338 (74.4)	
Retired	8 (2.5)	8 (7.1)	36 (7.9	
Missing			38 (8.4)	
Type of employment:				0.43
Legislators, senior officials and managers	0	1 (0.9)	1 (0.2)	
Professionals	4 (1.2)	2 (1.8)	6 (1.3)	
Technicians and associate professionals	3 (0.9)	1 (0.9)	4 (0.9)	
Clerks	4 (1.2)	3 (2.7)	7 (1.5)	
Service, shop and market sales workers	11 (3.4)	1 (0.9)	12 (2.6)	
Craft and related trade workers	4 (1.2)	3 (2.7)	7 (1.5)	
Plant and machine operators and assemblers	2 (0.6)	2 (1.8)	4 (0.9)	
Elementary occupations	21 (6.6)	9 (8.3)	30 (6.6)	
Armed forces	4 (1.2)	1 (0.9)	5 (1.1)	
Homemaker	266 (83.4)	85 (78.7)	351 (77.3)	
Missing			27 (5.9)	
Alcohol use history:				0.03
Formerly used alcohol products	6 (1.93)	8 (7.4)	14 (3.1)	
Currently use alcohol products	69 (22.2)	22 (20.4)	91 (20.0)	
Never used alcohol products	235 (75.8)	78 (72.2)	313 (68.9)	
Missing			36 (7.9)	
Tobacco use history:				0.90
Formerly used tobacco products	7 (2.2)	3 (2.8)	10 (2.2)	
Currently use tobacco products	62 (20.0)	20 (18.5)	82 (10.1)	
Never used tobacco products	241 (77.7)	85 (78.7)	326 (71.8)	
Missing			36 (7.9)	
Physical activity:				0.40
Low	59 (17.3)	18 (15.9)	77 (16.9)	
Moderate	183 (53.7)	54 (47.8)	237 (52.2)	
High	60 (17.6)	25 (22.1)	85 (18.7)	
Missing			55 (12.1)	
Hypertension treatment:				0.39
No	162 (48.5)	52 (46.4)	214 (47.1)	
Yes	172 (51.5)	60 (53.1)	232 (51.1)	
Missing			8 (1.8)	

Note: Data are number (%) or median (interquartile range).
*Difference between men and women by chi-square test for categorical variables and Mann–Whitney test for age.

Table 2: Anthropometric measurements, blood pressure and mean dietary intakes of study population

	Women			Men			
	Median	**25th**	**75th**	**Median**	**25th**	**75th**	$p^{\#}$
Variable							
Weight (kg)	84.0	69.5	100.0	70.0	59.0	84.0	< 0.0001
Height (cm)	157.0	153.00	161.0	169.0	163.0	174.0	< 0.0001
Body mass index (kg/m^2)	34.2	28.2	40.2	24.3	20.7	30.5	< 0.0001
Waist circumference (cm)	100	89	110	86	79	100.5	< 0.0001
Waist–hip ratio (WHR)	0.86	0.79	0.91	0.88	0.83	0.94	< 0.001
Waist-to-height ratio (WHtR)	0.63	0.57	0.70	0.52	0.47	0.60	< 0.0001
SBP (mmHg)	137.0	122.5	151.0	137.0	120.0	153.5	0.744
DBP (mmHg)	89.0	80.0	97.0	85.0	76.0	94.5	0.013
Dietary variable							
Energy intake (kJ)	6416.6	4719.4	8018.9	5932.5	4410.4	8108.1	NS
% total energy (protein)	15.1	13.3	16.8	15.0	13.2	16.8	NS
% total energy (fat)	27.0	21.8	31.6	26.6	21.0	31.5	NS
% total energy (satfat)	7.4	5.8	9.3	7.6	5.7	9.3	NS
% total energy MUFA	6.4	5.1	8.7	6.9	5.1	9.3	NS
% total energy PUFA	6.6	4.9	8.1	7	4.6	8.0	NS
% total energy (CHO)	54.1	48.8	60.3	52.9	49.8	60.9	NS
% total energy (added sugar)	8.4	5.6	12.2	8.3	5.6	13.4	NS
Total fibre intake (g)	19.4	14.6	23.7	18.8	13.5	23.5	NS
Diet score	41	37	44	42	36	46	NS

Note: MUFA: monounsaturated fat; PUFA: polyunsaturated fat; Satfat: saturated fat; CHO: carbohydrates.
[#]Comparison of variables of men and women by Mann–Whitney test.

recommendation of 6–10% of total energy, no association between intake of PUFA and SBP and DBP was found. In a recent study oily fish consumption of up to five servings per week resulted in a sustained decrease in SBP. This led the authors to conclude that the current recommendation for fish intake might be insufficient; they also found intakes of ≥ 6 servings per week did not have any additional benefits.[24] In the current study a positive correlation was observed between MUFA intake and SBP in the women's group. This finding is difficult to explain and different from the study of Rasmussen and colleagues,[25] who found that an increase in MUFA intake and a decrease in saturated fat intake resulted in a decrease in DBP. Furthermore, they also found that the beneficial effect of MUFA was lost in the presence of a total fat intake > 37%.[25]

In our study added sugar intake was positively correlated with SBP in the women. It has been suggested that an excessive intake of added sugar can result in increased blood pressure.[26] In addition an increased risk of stroke mortality has been associated with high carbohydrate intakes and high glycaemic index (GI) diets.[26] These findings resulted in a recommendation from the American Heart Association (AHA) of a reduction in added sugar and high GI carbohydrates consumption.[25] The role of diet (high salt, high fat, low fibre, low fruit and vegetables intake) in the development of hypertension is well documented.[2,23,27] This has led to a variety of dietary patterns such as the Mediterranean diet and DASH diet being developed in an attempt to prevent and treat hypertension.[5,28] Adherence to food based-dietary guidelines and diets in general is affected by many factors including globalisation, cultural beliefs, acceptability of recommended foods, socioeconomic status and level of education.[29] The indications of low adherence to dietary guidelines found in this study could be due to the fact that the majority of the participants were unemployed and of low SES, which influences food-purchasing behaviour.[30] Healthier food options are also perceived as being more costly in comparison with the less healthy options and often affordable healthier food options are not readily available in the community.[29] Lack of adherence to guidelines presents as overconsumption of unhealthy food leading to poor health outcomes. Adherence to guidelines has been shown to be effective in promoting general health, reducing all-cause mortality.[7,22,29]

Significant differences were observed between the gender groups in terms of their DBP and most anthropometric measurements. In this study WC, WHR and WHtR measurement was positively correlated with SBP and DBP in men and with DBP in women. In their study Sharaye and colleagues[31] found significant associations between WHtR and SBP and DBP in both men and women, and with WC and SBP in men only.[31]

Some 51% of the study sample was classified as being hypertensive (BP ≥ 140/90 mmHg). These findings corroborate a statement issued by the Heart and Stroke Foundation of South Africa (HSFSA) of a high prevalence of hypertension in South Africa.[27] The risk factors for the development of hypertension include obesity, especially central obesity, low levels of physical activity, a diet that is high in calories, fat, salt and refined carbohydrates, and low in fibre and fruit and vegetables, excessive alcohol use and tobacco use.[28]

In this study measures of abdominal obesity were positively correlated with SBP and DBP in men and with DBP in women. We used a WC cut-off value of 88 cm and 102 cm for females and males respectively, indicating substantially increased risk.[10,12] Recent studies in black South African populations have shown that the International Diabetes Federation (IDF) recommendations of WC cut-off values for abdominal obesity of ≥ 80 cm and ≥ 94 cm for females and males, respectively, overestimates the prevalence of metabolic syndrome in black populations.[32]

Table 3: Scoring criteria for dietary recommendations and intake for quintiles 1 to 5

	Q1 (1 point)		Q2 (2 points)		Q3 (3 points)		Q4 (4 points)		Q5 (5 points)		DASH or SAFBDG Recommendation per day
Variable	Median	Range	Median	Range	Median	Range	Median	Range	Median	Range	
MUFA (% TE)	4.36	2.97–4.89	5.30	4.93–5.76	6.41	5.78–7.20	8.31	7.2–9.28	11.8	9.3–12.1	10–12% of total energy
PUFA (% TE)	3.39	1.22–3.67	4.65	3.67–5.33	6.18	5.36–6.93	7.53	6.94–8.10	8.92	8.09–10.4	6 to < 10% of total energy
Fibre (g)	10.6	2.12–13.7	15.4	13.7–17.7	19.5	17.8–21.5	23.4	21.6–26.0	28.9	26.0–47.2	20–35 g
Dairy (g)	0	0–12.6	35.3	12.6–51.4	71.4	51.4–90	105.6	90–135.7	179.2	139–468	400–500 ml per day
Fish (g)	0	0–0	0	0–6	12	6–16	21.8	16.4–30	44.3	30–120	30 g per day (2–3 portions (80–90 g per week)
Legumes, nuts and seeds (g)	0	0–0	0	0–0	2	0–8	20	8.33–35.7	60	35.7–252	100–200 g per week (4–5 servings per week)
Fruit and vegetables (g)	103.9	0–160.3	213	161–260	298.5	261–336.7	390.1	337–452.8	560.4	458.7–886.3	400 g

Reverse score

	Q1 (5 points)		Q2 (4 points)		Q3 (3 points)		Q4 (2 points)		Q5 (1 point)		SAFBDG Recommendation per day
Variable	Median	Range	Median	Range	Median	Range	Median	Range	Median	Range	
Total fat (% TE)	17.9	6.7–19.5	20.0	19.7–20.1	22.9	20.2–28.2	30.7	28.8–32.4	35.4	32.5–45.3	20–30%of total energy
Satfat (% TE)	4.52	1.08–5.29	6.21	5.34–6.83	7.39	6.85–7.94	8.81	7.95–9.69	11.0	9.72–15.0	7–10% of total energy
Meat (g)	21.6	0–41	55.0	41–67.6	81.0	67.8–98	115.4	98.7–140	182.8	140.5–569.8	80–90 g per day
Added sugar (% TE)	3.04	0–4.55	5.79	4.57–6.8	7.97	6.81–9.30	10.7	9.33–12.8	17.0	12.9–33.7	≤ 10% of total energy
Alcohol (g)	0	0–0	0	0–0	0	0–0	14.9	0–60	142.9	61.2–33.7	≤ 24 g (F) and ≤ 45 g (M)
Sodium (mg)	2467.3	597.2–2941.7	3288.9	2982.3–3496.7	3650.4	3497.4–3776.3	3999.8	3784.6–4268.8	4652.3	4269.4–5966.6	< 2300 mg

Notes: MUFA: monounsaturated fatty acids.
PUFA: polyunsaturated fatty acids.
TE: total energy.
Satfat: saturated fat.

Table 4: Dietary intake and physical measurements according to tertiles of dietary adherence score

	Tertile 1 ($n = 151$)			Tertile 3 ($n = 152$)			
Variable	**Median**	**25th**	**75th**	**Median**	**25th**	**75th**	***p*-value**
Dietary score	28	26	29	44	42	45	< 0.0001
Total energy (kJ)	6944	5343	8181	5560	4436	7361	0.001
Protein (% TE)	15.3	13.2	17.3	15.6	14.1	17.2	0.496
Carbohydrates (% TE)	57.4	52.4	64.1	51.2	47.1	55.2	0.228
Fibre (g)	15.3	12.0	19.8	20.0	14.3	23.8	0.81
Sugar (% TE)	10.6	7.5	16.4	6.9	4.9	9.7	0.189
Fruit and vegetables (g)	32.8	0	77.9	383.3	312.4	494.8	< 0.0001
Legumes (g)	0	0	14.3	15.2	2.1	36.2	< 0.0001
Meat and meat products(g)	109	72.9	159.8	56.5	31	98.9	< 0.0001
Fish and fish products (g)	0	0	14.3	19.6	8.7	35.9	< 0.0001
Eggs (g)	0	0	22.1	51.4	26	71.4	< 0.0001
Dairy products (g)	32.8	0	77.9	102.1	65.6	160	< 0.0001
Alcohol (g)	189.1	115.3	291.9	0	0	11	0.006
Total fat (% TE)	27.0	21.8	31.6	26.1	21.0	30.8	0.28
Saturated fat (% TE)	7.92	6.38	10.24	7.6	5.7	9.3	0.001
MUFA (% TE)	5.90	5.02	7.68	5.3	4.5	6.9	0.005
PUFA (% TE)	5.1	3.5	6.98	7.7	6.5	9	0.079
Sodium (mg)	3842	3533	4362	3721	2658	3655	< 0.001
Age (years)	52	42	60	48.5	40	54	0.771
Weight (kg)	82	65.2	100.7	83.5	66.5	101	0.262
BMI (kg/m^2)	31.9	25.9	39.2	31.4	25.3	39.0	0.187
WC (cm)	97	86	107	97	85.3	110	0.567
WHR	0.86	0.79	0.93	0.86	0.80	0.91	0.121
WHtR	0.61	0.53	0.68	0.61	0.53	0.69	0.186
SBP (mmHg)	138	124	155	133.5	120	146.8	0.560
DBP (mmHg)	89	80	98	86.5	78	93	0.413

Notes: MUFA: monounsaturated fatty acids PUFA: polyunsaturated fatty acids.
BMI: body mass index; WC: waist circumference; WHR: waist–hip ratio; WHtR: waist-to-height ratio.
SBP: systolic blood pressure DBP: diastolic blood pressure.
**p*-value compare first and third tertile group (Mann–Whitney U test).

Almost 85% of our study sample had a WC above the IDF cut-off values for women and men, 64% had WHR values above sex-specific cut-points and 48% had WHtR above the cut-off value of 0.5.

In total, 76% ($n = 343$) of the study sample was classified as overweight/obese (BMI ≥ 25 kg/m^2). The link between hypertension and BMI has been established, including in a recent four-country cross-sectional study that investigated the burden of hypertension in sub-Saharan Africa.[33] Recently it has been suggested that WHtR is superior to BMI as an indicator of obesity and cardiometabolic risk.[11] Sugasri and colleagues found that as WHR, BMI, waist and hip circumference, and WHtR increased, the level of hypertension increased in their study participants.[27] Bombelli and colleagues found that an increase in both BMI and WC indices was associated with increases in SBP and DBP.[34]

Black South African females associate being overweight with self-esteem, contentment, good health and wealth and consider obesity acceptable and desirable.[35] This perception presents a major challenge since it influences willingness to lose weight and possibly adherence to dietary guidelines. Healthier food options are also perceived as being more costly in comparison with the less healthy options and often affordable healthier food options are not readily available in the community.[29] Langa, the community where this study was conducted, has a high unemployment rate.[36] Only 17% of the study sample were employed, which influenced the type of foods being purchased for consumption.

According to the SANHANES-1 report, the Western Cape province has the highest prevalence of smoking in South Africa.[37] Approximately 10% of the participants smoked in this study. Men were more likely than women to be current smokers. Smoking has been positively linked with increased blood pressure.[27] The current recommendation for physical activity (PA) is moderate-intensity PA of 30 minutes daily, which is equivalent to an energy expenditure of 3–6 metabolic equivalents (METs).[36] In the current study 52% of the participants reported that they were moderately active and approximately 19% reported having high levels of PA. Self-reported PA is considered not to be very accurate compared with direct PA measurement,[38] although the IPAQ questionnaire used in this study is considered to be a reliable instrument to test self-reported PA.[39] PA has been associated with lower blood pressure.[40]

A number of reasons could explain the lack of association between dietary adherence score, adiposity variables and blood pressure in the present study. Dietary adherence score was based on quintiles of the participants' actual self-reported intakes. This is not the ideal situation to assess the best adherence to the dietary guidelines. Therefore, even those with the highest scores could probably not be described as being 'adherent' to dietary guidelines. It is difficult to determine adherence,

Table 5: Correlation of anthropometric parameters and dietary intake with blood pressure

Variable	Women		Men	
	SBP	DBP	SBP	DBP
Age	0.399**	0.160**	0.422**	0.312**
Total energy (kJ)	−0.11**	−0.075	−0.102	−0.115
% TE protein	0.023	−0.06	0.026	−0.025
% TE fat	−0.083	−0.61	0.088	0.012
% TE saturated fat	−0.071	−0.059	0.083	0.022
% TE MUFA	0.154**	0.075	0.102	0.115
% TE PUFA	−0.106	−0.07	−0.049	−0.118
% TE carbohydrate	0.048	0.066	−0.031	0.048
% TE added sugar	0.116*	0.089	0.005	0.079
Total fibre intake	−0.107	−0.029	−0.156	−0.173
Sodium intake	−0.124*	−0.074	−0.053	−0.018
Dietary adherence score	−0.108*	−0.029	−0.065	−0.107
Tertile rank of dietary adherence score	−0.093	−0.070	−0.057	−0.069
Physical activity	−0.100	−0.85	−0.084	−0.134
Weight	0.009	0.079	0.210*	0.221*
Body mass index	0.037	0.085	0.219*	0.225*
Waist circumference	0.058	0.122*	0.340**	0.335**
Waist–hip ratio	0.077	0.126*	0.327**	0.234*
Waist-to-height ratio	0.089	0.151**	0.330**	0.313**

Notes: % TE: percentage of total energy.
% TE MUFA: percentage of total energy from monounsaturated fatty acids.
% TE PUFA: percentage of total energy from polyunsaturated fatty acids.
**Significant at 0.01 level (2-tailed test); *Significant at 0.05 level (2-tailed test).

because adherence measures depend on self-report. We used a validated QFFQ and the fieldworkers were trained on how to complete the QFFQ and determine portion sizes consumed with the highest accuracy possible in this setting. Self-reported intakes were then compared with dietary guidelines, modelled on methods proposed by Fung and colleagues.[2] Despite these carefully planned methods, it is still possible that participants with the highest adherence scores would not necessarily be the most adherent to dietary guidelines. Furthermore, a large proportion of the participants were on antihypertensive drugs; however, no information regarding their adherence to drug treatment was available. Non-adherence to antihypertensive drugs could have a more profound effect on their BP than adherence to a diet in line with the DASH guidelines. Obesity develops over time, thus recent adherence to dietary guidelines may not necessarily be associated with a more optimal body composition.

Table 6: Variables associated with hypertension in the logistic regression model*

Variable	Odds ratio (OR)	95% confidence intervals (CI)		p
Constant	0.21			0.22
Age	1.06	1.03	1.09	< 0.0001
Dietary adherence score	0.97	0.91	1.04	0.38
Physical activity:				
Inactive	Reference			
Moderately active	0.95	0.50	1.81	0.88
Highest activity	0.49	0.22	1.07	0.07

*Model with best fit, Hosmer and Lemeshow test, $p = 0.826$.

Limitations

The following limitations need to be considered. The high percentage of participants with missing values for physical measurements and the small number of male respondents might have influenced the results. The dietary adherence score was based on self-reported dietary intake, which is considered to be relatively inaccurate. As the budget of this study was insufficient to include biochemical measurements, we were unable to determine the levels of blood glucose or lipids. Finally, as this was a cross-sectional study no causal relationship can be inferred between any of the factors and hypertension.

Conclusion

This study revealed that even though the anthropometric measurements (BMI, WC, WHR and WHtR) of participants in the different adherence score tertile groups did not differ significantly, a significant negative correlation between the dietary adherence score and SBP in women was found.

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References

1. Lachat C, Otchere S, Roberfroid D, et al. Diet and physical activity for the prevention of noncommunicable diseases in low-and middle-

income countries: a systematic policy review. PLoS One. 2013;10(6): e1001465. doi:10.1371/journal.pmed.1001465
2. Fung TT, Chiuve SE, McCullough ML, et al. Adherence to a DASH-style diet and risk of coronary heart disease and stroke in women. Arch Intern Med. 2008;168(7):713–721.
3. Dixon LB, Subar AF, Peters U, et al. Adherence to the USDA food guide, DASH eating plan, and the Mediterranean dietary pattern reduce risk of colorectal adenoma. J Nutr. 2007;137:2443–2450.
4. Gibney M, Vorster H. South African food-based dietary guidelines. S Afr J Clin Nutr. 2001;14(3 Suppl.):S1–S80.
5. Vorster H. Food-based dietary guidelines for South Africa. S Afr J Clin Nutr. 2013;26(3 Suppl.):S3–S164.
6. Tangney CC, Staffileno BA, Rasmussen HE. Healthy eating: how do we define it and measure it? What's the evidence? J Nur Pract. 2017;13 (1):e7–e15. [cited 2017 Jul 10]. Available from: www.npjournal.org
7. Kim H, Andrade FCD. Diagnostic status of hypertension on adherence to the Dietary Approaches to Stop Hypertension (DASH) diet. Prev Med Rep. 2016;4:525–531.
8. Livingstone KM, Naughton SA. Diet quality is associated with obesity and hypertension in Australian adults: a cross-sectional study. BMC Public Health. 2016;16:235. [cited 2017 Jul 10]. doi:10.1186/s12889-016-3714-5
9. Nishida C, Ko GT, Kumanyika S. Body fat distribution and noncommunicable diseases in populations: overview of the 2008 WHO expert consultation on waist circumference and waist-hip ratio. Eur J Clin Nutr. 2010;64:2–5.
10. World Health Organization. Waist circumference and waist-hip ratio: report of a WHO expert consultation, Geneva, 8–11 December 2008. Available from: whqlidoc.who.int/publications/2011/9789241501491_eng.pdf
11. Ashwell M, Gibson S. A proposal for a primary screening tool: "Keep your waist circumference to less than half your height". BMC Med. 2014;12:20. Available from: http://bmcmedicine.biomedcentral.com/articles/10.1186/s12916-014-0207-1
12. Alberti KGMM, Eckel RH, Grundy SM, et al. 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.
13. Teo K, Chow CK, Vaz M, et al. The Prospective Urban Rural Epidemiology (PURE) study: examining the impact of societal influences on chronic noncommunicable diseases in low- , middle- and high-income countries. Am Heart J. 2009;158(1):1–7.e1.
14. Marfell-Jones MJ, Stewart AD, de Ridder JH. International standards for anthropometric assessment. The Society for the Advancement of Kinanthropometry, Wellington, New Zealand. 2012.
15. Wentzel-Viljoen E, Laubsher R, Kruger A. Using different approaches to assess the reproducibility of a culturally sensitive quantified food frequency questionnaire. S Afr J Clin. 2011;24(3):143–148.
16. Langenhoven ML, Conradie PJ, Wolmarans P, et al. MRC food quantities manual. 2nd ed. Cape Town: Medical Research Council; 1991. p. 1–213.
17. Wolmarans P, Danster N, Dalton A, et al., editors. Condensed food composition tables for South Africa. Cape Town: Medical Research Council; 2010. p. 1–126.
18. Lu H, Wu C, Howatt DA, et al. Differential effects of dietary sodium intake on blood pressure and atherosclerosis in hypercholesterolemic mice. J Nutr Bioch. 2013;24:49–53.
19. Lala MA, Nazar CMJ, Mauton BM, et al. Effects of dietary salt on blood pressure. Endo & Metab Syn. 2015;4:2. [cited 2017 Jul 3]. Available from: http://dx.doi.org/10.4172/2161-1071.1000175
20. McLean RM. Measuring population sodium intake: a review of methods. Nutrients. 2014;6:4651–4662.
21. Hassan NE, El Shebini SM, Ahmed NH, et al. . Association between macronutrients intake, visceral obesity and blood pressure in a sample of obese Egyptian women. Macedonian J Med Sci. 2015;3 (1):184–188.
22. Saneei P, Salehi-Abargouei A, Esmaillzadeh A, et al. Influence of Dietary Approaches to Stop Hypertension (DASH) diet on blood pressure: a systematic review and meta-analysis on randomized controlled trials. Nutr Metab & Card Dis. 2014;24:1253–1261.
23. Yang B, Shi M-Q, Li Z-H, et al. Fish, long-chain *n*-3 PUFA and incidence of elevated blood pressure: a meta-analysis of prospective cohort studies. Nutrients. 2016;8:58. doi:10.3390/nu8010058
24. Del Brutto OH, Mera RM, Gillman J, et al. Dietary oily fish intake and blood pressure levels: a population-based study. J Clin Hyperten. 2015. [cited 2016 Mar 13]. Available from: http://onlinelibrary.wiley.com/doi/10.1111/jch.12684
25. Rasmussen BM, Vesby B, Uusitupa M, et al. Effects of dietary saturated, monounsaturated, and n-3 fatty acids on blood pressure in healthy subjects. Am J Clin Nutr. 2006;83:221–226.
26. DiNicolantonio JJ, Lucan SC. The wrong white crystals: not salt but sugar as aetiological in hypertension and cardiometabolic disease. Open Heart. 2014;1:e000167. doi:10.1136/openhrt-2014-000167
27. Sugasri S, Lakshmi UK. Diet, lifestyle and hyperlipidemia as possible risk factors among hypertensive adults. Int J Appl Biol and Pharm Tech. 2012;3(1):123–129.
28. Van de Vijver S, Akinyi H, Oti S, et al. Status report on hypertension in Africa – Consultative review for the 6th session of the African Union Conference of Ministers of health on NCD's. Pan African Med J. 2013;16:38. doi:10.11604/pamj.2013.16.38.3100
29. Muzigaba M, Puoane T. Perceived and actual cost of healthier foods versus their less healthy alternative: a case study in a predominantly black urban township in South Africa. East Afr J Publ Health. 2011;8 (4):285–292.
30. Bonaccio M, Bonanni AE, Di Castelnuovo A, et al. Low income is associated with poor adherence to a Mediterranean diet and a higher prevalence of obesity: cross-sectional results from the Moli-Sani study. BMJ Open. 2012;2:e001685. doi:10.1136/bmjopen-2012-001685
31. Sharaye KO, Olorunshola KV, Ayo JO, et al. Correlation of obesity indices and blood pressure among non-obese adults in Zaria, Northern Nigerai. J Pub Health and Epid. 2014;6(1):8–13. doi:10.5897/JPHE2013.0590
32. Guwatudde D, Nankya-Mutyoba J, Kalyesbula R, et al. The burden of hypertension in sub-Saharan Africa: a four-country cross sectional study. BMC Public Health. 2015. doi:10.1186/s12889-015-2546-z
33. Motala AA, Esterhuizen T, Pirie FJ, et al. The prevalence of metabolic syndrome and determination of the optimal waist circumference cutoff points in a rural South African community. Diabetes Care. 2011;34:1032–1037. doi:10.2337/dc10-1921
34. Bombelli M, Facchetti R, Fodri D, et al. Impact of body mass index and waist circumference on the cardiovascular risk and all-cause death in a general population: data from the PAMELA study. Nutr Metab Cardio. 2013;23:650–656.
35. Peer N, Steyn K, Lombard C, et al. A high burden of hypertension in the urban Black population of Cape Town: the Cardiovascular Risk in black South Africans (CRIBSA) study. PLoS One. 2013;8(11):e78567. doi:10.1371/jornal.pone.0078567
36. Kurtze N, Rangul V, Hustvedt B-O, et al. Reliability and validity of self-reported physical activity in the Nord-Trøndelag Health Study – HUNT-1. Scan J Public Health. 2008;36:52–61.
37. Shisana O, Labadarios D, Rehle T, et al. South African national health and nutrition examination survey (SANHANES-1): human science research council. Cape Town: HSRC Press; 2013.
38. Prince SA, Adamo KB, Hamel ME, et al. A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review. Int J Behav Nutr Phys Act. 2008;5:56. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2588639/pdf/1479-5868-5-56.pdf
39. Salisbury Z, Goldsmith R, Rushton A. Systematic review of the measurement properties of self-report physical activity questionnaires in healthy adult populations. BMJ Open. 2015;5:e008430. doi:10.1136/bmjopen-2015-008430
40. Thijssen DH, Maiorana AJ, O'Driscoll G, et al. Impact of inactivity and exercise on the vasculature in humans. Eur J Appl Physiol. 2010;108:845–875.

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