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Research Article
Relationship Between Physical Activity, Selected Lifestyle Behaviour and Metabolic Disease Risk among Municipality Employees in South Africa

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Abstract
Background and Objective: Metabolic syndrome is a clustering of abdominal obesity, high blood pressure, high total cholesterol levels and impaired fasting blood glucose. The study examined the relationship between physical activity (PA) and selected lifestyle behaviour associated with metabolic disease risk among employees of Vhembe District Municipality, Limpopo Province of South Africa. **Materials and Methods:** A cross-sectional study was conducted among 468 (men = 222, women = 246) employees (aged 24-65 years). A standardised physical activity questionnaire by Sharkey was used to assess the physical activity index (PAI) of the participants. Height, weight and waist circumference (WC) were measured according to standard procedures and subsequently, body mass index was calculated as weight in kilogram divided by height in meter square (kg m^{-2}). Additionally, waist to height ratio (WHtR) was calculated as waist divided by height. Participants' selected lifestyle habits (smoking and alcohol consumption), anthropometric, blood pressure (BP), fasting glucose (FG) and total cholesterol (TC) measurements were determined using standardised protocols. **Results:** Fifty-five percent of the employees presented with metabolic syndrome, with higher percentage in males (87%) than females (26%). Among participants without MetS, alcohol consumption was positively correlated with diastolic blood pressure (DBP), systolic blood pressure (SBP), BMI and WC. BMI was also related with alcohol consumption, SBP with TC, FBG with WC and WHtR with SBP. Alcohol drinking was positively associated with WHtR. **Conclusion:** Low PA was positively associated with higher prevalence of metabolic risk factors. Health promotion and lifestyle education programmes to address the risk factors of metabolic syndrome among municipality employees are recommended.

Key words: Metabolic risk factors, physical activity, metabolic syndrome, lifestyle behaviour, diastolic blood pressure, systolic blood pressure, alcohol consumption

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Metabolic syndrome (MetS) is a clustering of abdominal obesity, high blood pressure (BP), high total cholesterol levels (TC) and impaired fasting blood glucose (FBG)[1]. In previous studies, metabolic syndrome has increased two fold the risk of cardiovascular disease and five to nine fold the risk of type 2 diabetes mellitus[2,3]. In addition, MetS has a 40% increased risk of cardiovascular disease mortality[4,5] and the prevalence of MetS varies around 20-45% among the global population[6,7]. However, the levels of MetS prevalence may vary greatly according to cut-off points of the National Cholesterol Education Program Adult Treatment Panel III and the International Diabetes Federation diagnostic criteria and the ethnic group studied[8]. In sub-Saharan Africa, the majority of countries are experiencing rapid demographic and epidemiological transition[9,10]. Available information from studies in African adult populations indicates a prevalence of MetS ranging from 0% to as high as about 50% or more[11]. Some studies of MetS incidence have been conducted at individual corporations and results indicated that its prevalence varies by occupation type[12].

In comparison with other categories of employees, shift workers were found as having a higher incidence of MetS[13], while a study of a Midwestern-manufacturing corporation in the USA found that 30.2% of employees met the criteria of MetS[14]. A study of 203 employees in a leading global energy company reported a MetS prevalence of 23.6% based on laboratory and medical aid data[15] The MetS prevalence of 22.6% reported in a global financial services corporation was associated with increased sick leave and rampant trend of short-term disability claims, but no significant association was found with the frequency of presenteeism or short-term disability[16].

In China, the prevalence of MetS was reported to be 10.6% and 4.3%, respectively in urban and rural areas[17] in 2002. However, MetS prevalence in rural China has dramatically increased and had reached 24.2% in 2014, because of rapid economic progress and lifestyle transitions in the country[2]. Davila *et al.*[18] established that the prevalence of MetS did not increase in shift workers only, but also among farm workers in the Boland District of Cape Town, South Africa. The study of cardiovascular Risk in Black South Africans (CRIBSA) has also reported a high prevalence of MetS (38.9%)[19]. Overall high prevalence of MetS in rural South African women was 30.2%, while a study in an urban area of Cape Town in 2012 revealed a MetS prevalence rate of 60.6%[20,21].

The most dominant causes of MetS are ageing, unhealthy diet and sedentary lifestyle[22,23]. The characteristics of work, including job types and long working hours are also associated with MetS[24,25,26]. The consumption of a western diet, meat and fried food promote the incidence of MetS[22]. Smoking and excessive alcohol drinking habits can also contribute to the development of MetS[27,28]. While smoking may increase the risk of low high-density lipoprotein cholesterol, high triglycerides and abdominal obesity[29], alcohol consumption was reported to be inversely associated with the risk of low high-density lipoprotein cholesterol, but showed an increasing positive dose-response relationship with the risk of MetS[30].

Several categories of employees in Taiwan are at high risk for the development of MetS[31]. In the Taiwanese workplace, wellness programmes have been proposed to prevent the development of MetS and such strategies focus mainly on promoting workers' PA and healthy eating habits[32] as research findings have indicated that regular leisure time PA could be beneficial for the prevention and/or management of MetS[33,34].

Several studies have reported that the effectiveness of leisure time PA in reducing MetS depends on the type, intensity, duration and frequency of activity[33,34,35]. Compared with a low level of leisure time PA, a high level of PA resulted in a lower risk of MetS, but a moderate level of leisure time PA was only weakly related to its reduced risk[33]. Therefore, in order to achieve beneficial health outcomes, it is recommended that one engages in at least 150 min of moderate intensity aerobic PA weekly and at least 75 min of vigorous intensity, or an equivalent blend of moderate and vigorous intensity PA[36].

The association of physical inactivity with the prevalence of MetS at work and in daily life has been found in various studies[37,38]. A study by Mendez-Hernandez *et al.*[39] reported that the risk of MetS decreased by 0.75% in a group with more than three hours of PA when at work compared with those in a category that was sedentary. Choi *et al.*[40] also reported that individuals with sedentary tasks and low PA levels among 1,001 US workers had a higher risk of abdominal obesity, which is the essential identifying factor of MetS. In addition, a study by Kim *et al.*[41], which analysed the risk of MetS for different occupational groups in South Korea, revealed that the relative risk for MetS was 1.25% higher among office workers than it was among non-office workers and that the PA level of the former category of workers was low. Therefore, the risk of MetS can be associated with PA levels according to a person's occupation[42]. The objective of this study was, therefore, to examine the relationship between physical activity, lifestyle behaviour and metabolic disease risk among employees in Vhembe District local municipality of Limpopo Province, South Africa.

MATERIALS AND METHODS

Study design: The research was based on a cross-sectional design involving a sample of local government employees in the Vhembe District Municipality of the Limpopo Province, South Africa.

Study area: The study was carried out at Vhembe District municipality satellites offices from July 2014-to-February 2016.

Study participants and sample size: Participants were 468 (Men = 222, Women = 246, Aged = 24-65 years) local government employees (local government is a form of public administration in South Africa which exists as the lowest tier of public administration in the provinces) in the Vhembe District, which is one of the 5 Districts of the Limpopo Province of South Africa. Vhembe District is located in the northern part of the country and shares its borders with Beitbridge District in Matabeleland South, Zimbabwe. According to the 2001 Census, 800,000 residents of Vhembe District speak Tshivenda as their mother tongue, while 400,000 speak Tsonga and 27,000 speak Northern Sotho[43]. For the purpose of this study, the employees were categorised into three age groups (24-29, 30-44 and 45-65 years), after they gave informed consent and were deemed apparently healthy[44]. The age categories for 24-44 years represented the sub-clinical horizon and pre-menopause population, whereas the age group 45-65 years represented the post-clinical horizon and post-menopausal population group. The municipality employees voluntarily participated in the study.

Parameters and measurement

Height and body mass: Height was measured to the nearest 0.1 cm, using a Harpenden Portable Stadiometer (Holtain Limited, Crymych, Dyfed, UK). Body mass was measured using a portable calibrated scale (SECA) and recorded to the nearest 0.5 kg. Body mass index (BMI) was calculated as:

$$\text{BMI} = \frac{\text{Body mass (kg)}}{\text{Height (m}^2\text{)}}$$

Waist circumference and waist-to-height: Waist circumference was measured with a steel tape using American College of Sports Medicine's (ACSM) protocol[44]. For men, low waist circumference is defined as less than 94 cm, high as 94-102 cm and very high as greater than 102 cm. For women, low WC is less than 80 cm, high is 80-88 cm and very high is greater than 88 cm (45-46)[45]. Waist-to-height ratio (WHtR) was determined as:

$$\text{WHtR} = \frac{\text{Waist circumferences (cm)}}{\text{Height (cm)}}$$

The norms for WHtR were categorized as follows: Normal-signifying WHtR<0.5 and WHtR>0.5 indicating increased risk for both males and females[46].

Cholesterol and glucose screening: Total blood cholesterol and blood glucose levels were determined after ten hours fast, using capillary blood samples obtained with a finger prick. The participants were informed a day before the test not to consume any food in the morning prior to the test, with their last meals taken before 10 pm the night before the test. After the measurements participants were allowed to take some snacks. The blood samples were placed on People Technology Service (PTS) panels (i.e. glucose and lipids test strips) and analysed using the Cardiochek® PA Analyser (Polymer technology systems, Inc., USA). The Cardiochek® analyser was calibrated regularly following the manufacturer's instructions.

Blood pressure: Blood pressure was measured using an automated aneroid sphygmomanometer (Omron, Health care, Inc., USA). The participants were comfortably seated for 15 min in a well-ventilated room before systolic (SBP) and diastolic (DBP) blood pressure measurements were taken based on the protocol of American College of Sports Medicine[44].

Measurement cut-off points: The American College of Sport Medicine has recommended the following thresholds above which individuals will be at increased risk for cardiovascular disease[44]:

- Overweight = BMI between 25-29.9 kg m^{-2}, Obesity = BMI $\geq$30kg m^{-2}
- Hypertension-systolic blood pressure $\geq$140 mm Hg, diastolic blood spressure $\geq$90 mm Hg
- Total cholesterol $\geq$5.18 mmol L^{-1} or patient using lipid-lowering drugs
- Impaired fasting glucose (FG) $\geq$5.5 mmol L^{-1} or patient using diabetic mellitus medication

Assessment of smoking and alcohol drinking habits: In line with the objective of this study, lifestyle habits were delimited to information regarding smoking and alcohol drinking collected using the Belloc and Breslow's listed seven lifestyle habits associated with general health[47]. The questionnaire which was based on yes or no answers without specifying quantity of intake, requested the participants whether or not he/she smokes and drinks alcohol.

Subjective assessment of physical activity: The physical activity index (PAI) questionnaire developed by Sharkey[48] was used to assess the participants' PAI. The training principles, namely frequency, duration and intensity, were reported by each respondent retrospectively and these were used to determine their PAI. Respondents were then classified into low active (PAI = <16), moderate active (PAI 17-44) and high active (PAI = >45) groups[48].

Definition or metabolic syndrome criteria: The criteria of International Diabetes Federation (IDF) for diagnosis of MetS and the 2005 revised National Cholesterol Education Program Adult Treatment Panel (NCEP-ATP) III criteria as proposed by the AHA/NHLB were used[49]. The revised NCEP criteria require at least three of the following components[50]:

- Abdominal obesity: Waist circumference (WC) $\geq$102 cm (>40) in men or $\geq$88 cm (>35) in women
- Serum triglycerides (TGs): $\geq$150 mg dL^{-1} ($\geq$1.7 mmol L^{-1})
- High-density lipoprotein-cholesterol (HDL-C): <40 mg dL^{-1} (<1.03 mmol L^{-1}) in men or <50 mg dL^{-1} (<1.29 mmol L^{-1}) in women
- Fasting blood glucose (FBG) level: $\geq$100 mg dL^{-1} ($\geq$5.6 mmol L^{-1})
- Blood pressure (BP): $\geq$130/85 mm Hg

For National Cholesterol Education Program (NCEP) criteria, abdominal obesity is a component of the syndrome, but not a prerequisite for diagnosis. The IDF criteria of MetS use central obesity (waist circumference $\geq$90 cm for South Asian men or $\geq$80 cm for South Asian women) as a mandatory indicator and the presence of at least two of the other four criteria, which are identical to those provided by NCEP-ATPIII[51].

Statistical analysis: Data were analysed using SPSS for Windows version 24.0. Categorical variables were presented as frequency and percentages while quantitative variables were presented as mean and standard deviations. An independent t-test was used to compare the cardio-metabolic risks among gender. The characteristics of the participants who presented with MetS and those without were compared using ANOVA for normally distributed data. A Mann-Whitney U test was applied to determine the differences between the two MetS groups and Chi-square statistics were computed to determine the differences in the categorical variables. Spearman rho correlation coefficients (r) were calculated separately for the participants who presented with MetS and those without MetS to determine the relationship between physical activity and selected lifestyle behaviour associated with metabolic disease risk. Odd ratios (ORs) and 95% confidence interval (CIs) were estimated using a logistic regression analysis to predict the relationship between PA and MetS. Two dummy variables were created for PA (Dummy 1 = Low PA, Dummy 2 = Moderate-to-vigorous PA). The logistic regression model was used as adjusted for each potential confounders in the analysis. Ordinal variables (PA dummies) were used as continuous parameters to test the linear trend. The potential confounding variables, that is, age, smoking, drinking, occupation and education were included in the logistic regression model. All p-values were based on two-tailed test with a p-value of $\leq$0.05 considered statistically significant.

RESULTS

Participants' descriptive information: Table 1 indicates that out of the 468 employees, the majority (83%) worked as ground maintenance staff, with few in skilled positions (17%) and most of them had no formal education (69%). Women with MetS (80%) were generally physically inactive compared to their male (72%) counterparts. The results also showed that 29% of employees consumed alcohol and 51% were smokers. The prevalence was more pronounced in men and women participants with the presence of MetS.

Gender differences in employees' MetS categories: Presented in Table 2 are the employees' MetS categories evaluated according to the NCEP-ATPIII and IDF criteria. In total, 45% had no MetS according to these criteria, whereas 55% had MetS or used medication according to NCEP-ATPIII and IDF benchmarks. When analysed according to gender, the results showed that males (87%) had a higher percentage of MetS than females (26%) (Table 2). The results also showed significant gender differences for the categories of MetS assessed according to NCEP-ATPIII and IDF (p=0.00).

The mean ages for MetS and non-MetS participants were as follows: men (53.40$\pm$7.86 years and 53.06$\pm$7.98 years) and women (53.74$\pm$8.05 years and 48.00$\pm$12.47 years, p<0.001) (Table 3). In term of the absence of MetS, men were significantly (p<0.001) taller (171.36$\pm$7.87 vs 160.08$\pm$7.19) and heavier (95.55$\pm$15.73 vs 84.84$\pm$16.12) than the women. Similarly, in the presence of MetS, men were significantly (p<0.001) taller and heavier than their counterparts' women. In both groups (i.e. no MetS and presence of MetS), significant

Table 1: Percentages (%) for categorical variables for MetS and non-MetS according to men and women participants

Parameters	All participants Mean±SD Number (%)	Men (n = 222) MetS participants (n = 192) Mean±SD Number (%)	Men (n = 222) Non-MetS participants (n = 30) Mean±SD Number (%)	Women (n = 246) MetS participants (n = 181) Mean±SD Number (%)	Women (n = 246) Non-MetS participants (n = 65) Mean±SD Number (%)
BMI categories					
Underweight (%)	16 (03)	15 (8)	0 (0)	1 (2)	0 (0)
Normal weight (%)	178 (38)	120 (63)	3 (10)	41 (63)	14 (8)
Overweight (%)	121 (26)	43 (22)	6 (20)	19 (29)	53 (29)
Obesity (%)	153 (33)	14 (7)	21 (70)	4 (6)	114 (63)
Blood pressure categories					
Normal (%)	351 (75)	150 (78)	23 (77)	59 (91)	119 (66)
Hypertension (%)	117 (25)	42 (22)	7 (23)	6 (9)	62 (34)
Education (%)					
No formal education	324 (69)	139 (73)	19 (63)	40 (62)	126 (70)
Std 8	24 (5)	12 (6)	4 (13)	0 (0)	8 (4)
Matric	45 (10)	15 (8)	2 (7)	6 (9)	22 (12)
Diploma	43 (9)	15 (8)	2 (7)	12 (19)	14 (8)
Degree 1	7 (2)	3 (2)	1 (3.3)	0 (0)	3 (2)
Degree2	1 (0.2)	0 (0)	0 (0)	1 (2)	0 (0)
Degree 3	12 (3)	4 (2)	1 (3.3)	3 (5)	4 (2)
Degree4	9 (2)	3 (2)	1 (3.3)	3 (5)	2 (1)
Certificate	3 (0.6)	1 (0.5)	0 (0)	0 (0)	2 (1)
Occupation					
General clerk	42 (9)	21 (11)	3 (10)	2 (3)	16 (9)
Accounting clerk	12 (3)	2 (1)	0 (0)	2 (3)	8 (4)
Grounds maintenance workers	398 (83)	166 (87)	26 (87)	56 (86)	150 (83)
Municipality manager MM	9 (2)	3 (1)	1 (3)	3 (5)	2 (1)
Councillor	7 (3)	0 (0)	0 (0)	2 (3)	5 (3)
Alcohol consumption					
Yes	134 (29)	76 (40)	8 (27)	16 (25)	34 (19)
No	334 (71)	116 (60)	22 (73)	49 (75)	147 (81)
Do you smoke?					
Yes	238 (51)	87 (45)	12 (40)	38 (59)	101 (56)
No	230 (49)	104 (54)	18 (60)	27 (41)	80 (44)
PAI per week					
PAI <16 low activity	362 (77)	138 (72)	19 (63)	52 (80)	153 (85)
PAI between 17-44 Moderately PA	102 (22)	54 (28)	11 (37)	12 (19)	25 (14)
PAI >45 highly active	4 (1)	0 (0)	0 (0)	1 (1)	3 (1)

PAI: Physical activity index

Table 2: Gender differences in metabolic syndrome categories according to NCEP-ATPIII and IDF diagnostic criteria

MetS categories (%)	All participants	Men (n = 222)	Women (n = 246)	p-values
No MetS according to NCEP-ATPIII and IDF (%)	211 (45%)	30 (13%)	181 (74%)	0.00*
Presence of MetS or use of medication according to NCEP-ATPIII and IDF (%)	257 (55%)	192 (87%)	65 (26%)	0.00*

*$p \leq 0.05$: Significant

gender differences were found for WC with high mean values in men than women. Significant gender differences (p<0.05) were observed for SBP, DBP and FG, with high mean values in men than women, in the participants who presented with MetS.

Relationship between metabolic risk and its components among MetS and non-MetS categories: Table 4 presents the relationship between metabolic risk factors and their components among MetS and non-MetS categories, according to NCEP-ATPIII and IDF diagnostic criteria for the total participants. In terms of the participants without MetS, alcohol was significantly positively correlated with DBP (r = 0.20, p = 0.004) and SBP related strongly with BMI and waist circumference. Smoking positively correlated with DBP (r = 0.16) in participants with MetS. In addition, SBP correlated positively with WHtR (r = 0.24, p = 0.01). BMI was also associated with alcohol consumption (r = 0.28, p = 0.000), SBP

Table 3: Mean and standard deviations and p-value of the differences for men and women stratified by metabolic syndrome status and gender*

		No MetS according NCEP-ATPIII and IDF				Presence of METs or use of medication according to NCEP-ATPIII and IDF			
Physiological and MetS variables	Gender	N	Mean	SD	p-value of gender differences	N	Mean	SD	p-value of gender differences
Age (Year)	Men	30	53.40	7.87	0.83	192	53.06	7.90	<0.001
	Women	181	53.74	8.05		65	48.00	12.47	
Height (cm)	Men	30	171.36	6.58	<0.001	192	169.47	10.21	<0.0001
	Women	181	160.08	7.19		65	160.46	8.53	
Weight (kg)	Men	30	95.55	15.73	0.001	192	69.83	12.04	<0.001
	Women	181	84.84	16.12		65	64.58	8.98	
BMI (kg m^{-2})	Men	30	32.45	4.67	0.56	192	24.48	4.91	0.23
	Women	181	33.11	5.91		65	25.17	3.71	
WC (cm)	Men	30	114.49	16.22	<0.001	192	86.38	10.01	<0.001
	Women	181	102.50	12.06		65	78.30	8.89	
WHtR	Men	30	0.66	0.087	0.22	192	0.51	0.07	0.01
	Women	181	0.64	0.074		65	0.49	0.06	
SBP (mm Hg)	Men	30	141.83	21.49	0.59	192	140.31	22.11	<0.001
	Women	181	144.40	24.71		65	131.26	21.82	
DBP (mm Hg)	Men	30	80.33	10.61	0.20	192	79.05	13.67	0.04
	Women	181	83.59	13.20		65	75.68	10.08	
FBG (mg)	Men	30	9.53	8.49	0.01	192	6.50	5.34	0.05
	Women	181	7.04	4.15		65	5.64	1.72	
TC (mg)	Men	30	4.73	1.30	0.49	192	4.71	1.44	0.81
	Women	181	4.91	1.32		65	4.75	1.20	

BMI: Body mass index, WC: Waist circumference, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, FBG: Fasting glucose, TC: Total cholesterol, N: Number, SD: Standard deviation, *$p \leq 0.001$: Significant

Table 4: Relationship of metabolic risk and its components among MetS- and non-MetS categories

No MetS	Values	BMI	WC	SBP	DBP	PAI index	TC	FBG	WhtR
BMI (kg m^{-2})	r	-	0.59**	0.18**	0.27**	-0.09	-0.04	0.10	0.63**
	p	-	<0.001	0.01	<0.001	0.17	0.55	0.15	<0.001
WC (cm)	r	0.59**	-	0.23**	0.20**	-0.00	-0.08	0.21**	0.83**
	p	<0.001	-	<0.001	<0.001	0.96	0.22	<0.001	<0.001
SBP (mm Hg)	r	0.18**	0.23**	-	0.57**	-0.07	0.22**	-0.05	0.27**
	p	0.01	<0.001	-	<0.001	0.31	<0.001	0.45	<0.001
DBP (mm Hg)	r	0.27**	0.20**	0.57**	-	-0.08	0.17*	-0.02	0.23**
	p	0.00	0.00	0.00	-	0.25	0.01	0.71	0.001
PAI Index	r	-0.09	-0.00	-0.07	-0.08	-	-0.00	-0.04	-0.11
	p	0.17	0.96	0.31	0.25	-	0.97	0.54	0.10
Smoking	r	0.07	0.05	0.08	0.09	-0.03	-0.09	0.09	-0.00
	p	0.33	0.50	0.21	0.20	0.63	0.19	0.20	0.96
Alcohol	r	0.05	-0.03	0.02	0.20**	-0.04	-0.04	-0.13	-0.06
	p	0.46	0.69	0.72	<0.001	0.58	0.53	0.05	0.40
Presence of MetS or use of medication									
BMI (kgm^{-2})	r	-	0.56**	0.04	0.05	-0.09	0.06	0.07	0.67**
	p	-	<0.001	0.49	0.44	0.16	0.32	0.28	<0.001
WC (cm)	r	0.56**	-	0.22**	0.11	0.01	0.03	0.14*	0.86**
	p	<0.001	-	<0.001	0.07	0.81	0.65	0.02	<0.001
SBP (mm Hg)	r	0.04	0.22**	-	0.52**	0-.06	0.17**	-0.01	0.24**
	p	0.49	<0.001	-	<0.001	0.31	0.01	0.79	<0.001
DBP (mm Hg)	r	0.05	0.11	0.52**	-	-0.02	0.08	0.004	0.110
	p	0.44	0.07	<0.001	-	0.75	0.20	0.94	0.070
PAI Index	r	-0.09	0.01	-0.06	-0.02	-	-0.07	-0.01	-0.030
	p	0.16	0.81	0.31	0.75	-	0.26	0.80	0.610
Smoking	r	-0.01	0.07	0.03	0.16*	-0.05	-0.01	0.02	0.040
	p	0.85	0.24	0.59	0.01	0.38	0.90	0.70	0.510
Alcohol	r	0.28**	0.11	-0.14*	-0.05	-0.00	0.09	-0.04	0.17**
	p	<0.001	0.07	0.02	0.38	0.99	0.13	0.52	<0.001

BMI: Body mass index, WC: Waist circumference, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, WhtR: Waist to height ratio, TC: Total cholesterol, FBG: Fasting blood glucose, **Correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed)

Table 5: Odd ratios (OR) for the prevalence of MetS according to physical activity level for the total group by gender

Parameters	Univariate crude OR (95%CI)	Multivariate adjusted OR (95% CI)
Total group		
Moderate to high PA	1	1
Low PA	1.17 (1.03-1.33)	2.85 (0.39-20.98)#
Men		
Moderate to high PA	1	1
Low PA	0.83 (0.58-1.17)	5.20 (1.77-15.28)*
Women		
Moderate to high PA	1	1
Low PA	1.10 (0.92-1.31)	2.78 (0.37-21.41)

#Adjusted for gender, age, smoking, alcohol, PA, BMI, *Adjusted for age, smoking, alcohol, BMI

with TC (r = 0.17, p = 0.01), FBG with WC (r = 0.14, p = 0.02) and WHtR with SBP (r = 0.24, p = 0.000). Interestingly, alcohol drinking was negatively related with systolic blood pressure (r = -0.14, p = 0.02) among the participants with no MetS. Positive correlations were found between PA and components of MetS.

Odds ratio for the prevalence of MetS according to physical activity level by gender: The results of logistic regression analyses that examined the prevalence of MetS according to PA levels for the total group and by gender are presented in Table 5. In all the analyses, the group that met the PA reference standard for moderate to high PA (PAI between 17 and 45 and PAI $\geq$45) was used as the reference category. For the total group, the results showed that employees with low physical activity had a higher likelihood (OR: 1.17, 95% CI: 1.03-1.33) of developing MetS compared to those who engage in moderate to high PA. After adjusting for age, smoking, alcohol and BMI, the risk of MetS though not significant, increased [OR: 2.85, 95%CI: 0.39-20.98] in the low PA group. In men with a low PA level, the risk of MetS was significantly higher than those in the moderate to high active group, after adjusting for age, smoking, alcohol, BMI [OR: 5.20, 95% CI: 1.77-15.28]. In contrast, the risk for MetS in women was not significantly different between those in the moderate to high PA category and their counterparts with low PA after adjusting for age, smoking, drinking, occupation and education [OR: 2.78, 95% CI: 0.37-21.41].

DISCUSSION

This study examined the relationship between PA and lifestyle behaviour associated with MetS risk factors among employees in the Vhembe District local municipality, South Africa. The results showed that age and high BMI, as well as behavioural factors such as smoking and drinking, were positively associated with increased risk of metabolic syndrome in men and women employees. Overall, the prevalence of MetS among the employees, according to NCEP-ATPIII and IDF criteria, was 55% (87% in men and 26% in women). Low PA was related with the risk of MetS in men compared to women, whilst alcohol consumption was associated with abdominal fat. The prevalence of MetS in the study is higher than the 23.3% reported previously in Durban, South Africa[52] and those found in other countries such as Thailand (22.8%)[53] and India (41.4%)[54]. The higher prevalence of MetS in our study could be explained in light of the different criteria used for MetS diagnosis, such as IDF, WHO and NCEP-ATPIII. Therefore, the prevalence of MetS could be different even in the same population depending on the diagnostic criteria used in studies[55].

Other factors such as diet, nutrition, physical inactivity and genetic background could have contributed to the high prevalence of MetS[56]. Therefore, in view of its implications (that individuals with MetS are prone to increased risk of cardiovascular mortality), municipality health practitioners should take note of the present results to design employee wellness promotion programmes[4,5]. With regard to PA levels, women (80%) with MetS were reported to be more physically inactive compared to their male (72%) counterparts. These findings showed that physical inactivity might increase the risk of many adverse health conditions, including major non-communicable diseases such as coronary heart diseases and type 2 diabetes and could shorten life expectancy among employees[57].

Our results further showed positive associations between low PA and MetS risk factors, such as obesity and hypertension among male municipality employees. Kohli and Greenland[58] reported similar findings-that the lack of PA increased the risk of obesity, diabetes and hypertension, which, in turn, increased proneness to MetS.

In terms of the participants without MetS, alcohol consumption was significant and positively correlated with DBP and again alcohol was positively related with SBP, BMI and waist circumference. The findings are consistent with those of Kruger and Nell[59], which indicated that alcohol consumption was positively associated with SBP, DBP, BMI and WC in a community of farm workers in the Boland district, South Africa. In addition, drinking alcohol was associated with abdominal fat in participants who presented with MetS. The observed significant association between alcohol drinking and abdominal fatness in the current study is somewhat similar to the findings on the Danish cohorts of adults whereby, alcohol was associated with a higher sum of WC and BMI among women (0.5 mm per drink/day ($r = 0.2$, 0.9, $p = 0.002$)))[60]. However, the findings were contrary to the results of Beulens *et al.*[61] which stated that moderate alcohol consumption for 4 weeks was not associated with differences in subcutaneous and abdominal fat contents or body weight. These contrary findings could be attributed to the fact that in our study participants were classified based on the presence and absence of MetS. The results also showed a negative relationship between alcohol drinking and systolic blood pressure among the participants with the presence of MetS. The observed negative relationship may be explained by the small number of participants, i.e. 92 out of 468. In a review study by Roerecke *et al.*[62], it was reported that people who took six or more drinks per day experienced a reduction in systolic blood pressure, whereas in the study such information was not available thereby limiting possible comparison. The present results, which showed that smoking was positively correlated with DBP, contradict those of a study where no consistent association was found between smoking and BP or FBG among adult participants in the northeast region of the Netherlands.[29] It is well known that smoking raises sympathetic activity and increases the circulating cortisol, catecholamine's, vasopressin and growth hormone levels[63] and is consequently detrimental to health. Therefore, smoking plays a causal role in the development of MetS[64]. An assessment of the nutritional intake of municipality employees could have elucidated the relationship between nutrition and risk factors of MetS, but this was not feasible in the present study. Additionally, the questionnaire used in the study had limitations (e.g. example, the questions used to gather information regarding the number of cigarette or quantity of alcohol drinks), because it could not provide exact number of the quantity related to all variables of interest. It is also possible that the participants may not have correctly recalled the information required in the questionnaire. Despite these limitations, the present findings aided understanding of the association between PA, lifestyle behaviour and metabolic disease risk among South African municipality employees.

CONCLUSION

The prevalence of MetS factors in relation to lifestyle behaviour among employees in the Vhembe local municipality is alarmingly high. The results also showed that low PA is associated with a higher prevalence of MetS risk factors, more especially among male employees. Consumption of alcohol was associated with elevated abdominal fat. Future studies should, therefore, not only focus on developing specific criteria for MetS diagnosis among Africans but also acknowledge every effort made to educate the employees about its risk factors and the proper use of therapeutics or other nutritional and/or exercise interventions for the prevention of MetS among municipality employees.

SIGNIFICANCE STATEMENT

In a rare study among a cohort of South African municipality employees, low PA was positively associated with relatively higher prevalence of metabolic syndrome. Based on the current findings researchers will be guided to develop health promotion intervention and lifestyle education programmes targeted at reducing the risk factors of metabolic syndrome and its comorbidities among municipality employees. Such intervention programmes would have positive health outcomes and enhance productivity in the workplace.

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REFERENCES

1. Deepa, M., S. Farooq, M. Datta, R. Deepa and V. Mohan, 2007. Prevalence of metabolic syndrome using WHO, ATPIII and IDF definitions in Asian Indians: The Chennai Urban Rural Epidemiology Study (CURES-34). Diabetes/Metab. Res. Rev., 23: 127-134.

2. Zhao, Y., H. Yan, R. Yang, Q. Li, S. Dang and Y. Wang, 2014. Prevalence and determinants of metabolic syndrome among adults in a rural area of Northwest China. PLoS ONE, Vol. 9. 10.1371/journal.pone.0091578
3. Bhanushali, C.J., K. Kumar, A.K. Wutoh, S. Karavatas, M.J. Habib, M. Daniel and E. Lee, 2013. Association between lifestyle factors and metabolic syndrome among African Americans in the United States. J. Nutr. Metab., Vol. 2013. 10.1155/2013/516475
4. Prasad, D.S., Z. Kabir, A.K. Dash and B.C. Das, 2012. Prevalence and risk factors for metabolic syndrome in Asian Indians: A community study from urban Eastern India. J. Cardiovasc. Dis. Res., 3: 204-211.
5. Isomaa, B., P. Almgren, T. Tuomi, B. Forsen and K. Lahti *et al*., 2001. Cardiovascular morbidity and mortality associated with the metabolic syndrome. Diabetes Care, 24: 683-689.
6. Villegas, R., Y.B. Xiang, G. Yang, Q. Cai and S. Fazio *et al*., 2009. Prevalence and determinants of metabolic syndrome according to three definitions in middle-aged Chinese men. Metab. Syndr. Relat. Disord., 7: 37-45.
7. Ramli, A.S., A.M. Daher, M.N.K. Nor-Ashikin, N. Mat-Nasir and K.K. Ng *et al*., 2013. JIS definition identified more Malaysian adults with metabolic syndrome compared to the NCEP-ATP III and IDF criteria. BioMed Res. Int., Vol. 2013. 10.1155/2013/760963.
8. Grundy, S.M., 2008. Metabolic syndrome pandemic. Arterioscler. Thromb. Vasc. Biol., 28: 629-636.
9. WHO., 2010. Global Recommendations on Physical Activity for Health. World Health Organization, Geneva, Switzerland, ISBN-13: 9789241599979, Pages: 58.
10. Yusuf, S., S. Reddy, S. Ounpuu and S. Anand, 2001. Global burden of cardiovascular diseases. Part I: General considerations, the epidemiologic transition, risk factors and impact of urbanization. Circulation, 104: 2746-2753.
11. Okafor, C.I., 2012. The metabolic syndrome in Africa: Current trends. Indian J. Endocrinol. Metab., 16: 56-66.
12. Burton, W.N., C.Y. Chen, X. Li, A. B. Schultz and H. Abrahamsson, 2014. The association of self-reported employee physical activity with metabolic syndrome, health care costs, absenteeism and presenteeism. J. Occup. Environ. Med., 56: 919-926.
13. Lin, Y.C., T.J. Hsiao and P.C. Chen, 2009. Persistent rotating shift-work exposure accelerates development of metabolic syndrome among middle-aged female employees: A five-year follow-up. Chronobiol. Int., 26: 740-755.
14. Wayne, P.M., B.J. Gow, M. D. Costa, C.K. Peng and L.A. Lipsitz *et al*., 2014. Complexity-based measures inform effects of Tai Chi training on standing postural control: Cross-sectional and randomized trial studies. PLoS ONE, Vol. 9. 10.1371/journal.pone.011473.
15. Birnbaum, H.G., M.E. Mattson, S. Kashima and T.E. Williamson, 2011. Prevalence rates and costs of metabolic syndrome and associated risk factors using employees' integrated laboratory data and health care claims. J. Occup. Environ. Med., 53: 27-33.
16. Burton, W.N., C.Y. Chen, A.B. Schultz and D.W. Edington, 2008. The prevalence of metabolic syndrome in an employed population and the impact on health and productivity. J. Occup. Environ. Med., 50: 1139-1148.
17. Lao, X.Q., Y.H. Zhang, M.C.S. Wong, Y.J. Xu and H.F. Xu *et al*., 2012. The prevalence of metabolic syndrome and cardiovascular risk factors in adults in Southern China. BMC Public Health, Vol. 12. 10.1186/1471-2458-12-64.
18. Davila, E. P., H. Florez, L. E. Fleming, D.J. Lee and E. Goodman *et al*., 2010. Prevalence of the metabolic syndrome among U.S. workers. Diabetes Care, 33: 2390-2395.
19. Peer, N., K. Steyn, C. Lombard, N. Gwebushe and N. Levitt, 2013. A high burden of hypertension in the urban black population of Cape Town: The Cardiovascular Risk in Black South Africans (CRIBSA) study. PLoS ONE, Vol. 8. 10.1371/journal.pone.007856.
20. Motala, A.A., T. Esterhuizen, F.J. Pirie and M.A. Omar, 2011. The prevalence of metabolic syndrome and determination of the optimal waist circumference cutoff points in a rural South African community. Diabetes C0are, 34: 1032-1037.
21. Erasmus, R.T., D.J. Soita, M.S. Hassan, E. Blanco-Blanco, Z. Vergotine, A.P. Kengne and T.E. Matsha, 2012. High prevalence of diabetes mellitus and metabolic syndrome in a South African coloured population: Baseline data of a study in Bellville, Cape Town. S. Afr. Med. J., 102: 841-844.
22. Lutsey, P.L., L.M. Steffen and J. Stevens, 2008. Dietary intake and the development of the metabolic syndrome: The atherosclerosis risk in communities study. Circulation, 117: 754-761.
23. Churilla, J.R. and E.C. Fitzhugh, 2012. Total physical activity volume, physical activity intensity and metabolic syndrome: 1999-2004 National Health and Nutrition Examination Survey. Metab. Syndr. Relat. Disord., 10: 70-76.
24. Almadi, T., I. Cathers and C.M. Chow, 2013. Associations among work-related stress, cortisol, inflammation and metabolic syndrome. Psychophysiology, 50: 821-830.
25. Kwon, C.S. and J.H. Lee, 2013. The association between type of work and insulin resistance and the metabolic syndrome in middle-aged Korean men: Results from the Korean National Health and Nutrition Examination Survey IV (2007~2009). World J. Men's Health, 31: 232-238.
26. Violanti, J.M., C.M. Burchfiel, T.A. Hartley, A. Mnatsakanova and D. Fekedulegn *et al*., 2009. Atypical work hours and metabolic syndrome among police officers. Arch. Environ. Occup. Health, 64: 194-201.

27. Corwin, E.J., C.S. McCoy, C.A. Whetzel, R.M. Ceballos and L.C. Klein, 2006. Risk indicators of metabolic syndrome in young adults: A preliminary investigation on the influence of tobacco smoke exposure and gender. Heart Lung, 35: 119-129.
28. Lee, K.W., B.J. Park, H.T. Kang and Y.J. Lee, 2011. Alcohol-drinking patterns and metabolic syndrome risk: The 2007 Korean National Health and Nutrition Examination Survey. Alcohol, 45: 499-505.
29. Slagter, S.N., J.V. van Vliet-Ostaptchouk, J.M. Vonk, H.M. Boezen and R.P. Dullaart *et al*., 2013. Associations between smoking, components of metabolic syndrome and lipoprotein particle size. BMC Med., Vol. 11. 10.1186/1741-7015-11-195.
30. Yoon, Y.S., S.W. Oh, H.W. Baik, H.S. Park and W.Y. Kim, 2004. Alcohol consumption and the metabolic syndrome in Korean adults: The 1998 Korean National Health and Nutrition Examination Survey. Am. J. Clin. Nutr., 80: 217-224.
31. Huang, J.H., R.H. Li, S.L. Huang, H.K. Sia, S.S. Lee, W.H. Wang and F.C. Tang, 2017. Relationships between different types of physical activity and metabolic syndrome among Taiwanese workers. Scient. Rep., Vol. 7. 10.1038/s41598-017-13872-5
32. Sia, H.K., Y.C. Su and F.C. Tang, 2012. Workplace health promotion in practice for metabolic syndrome. Ind. Saf. Hyg., 276: 38-42, (In Chinese).
33. He, D., B. Xi, J. Xue, P. Huai, M. Zhang and J. Li, 2014. Association between leisure time physical activity and metabolic syndrome: A meta-analysis of prospective cohort studies. Endocrine, 46: 231-240.
34. Park, M.Y., S.H. Kim, Y.J. Cho, R.H. Chung and K.T. Lee, 2014. Association of leisure time physical activity and metabolic syndrome over 40 years. Korean J. Family Med., 35: 65-73.
35. Bergstrom, G., C. Behre and C. Schmidt, 2012. Increased leisure-time physical activity is associated with lower prevalence of the metabolic syndrome in 64-year old women with impaired glucose tolerance. Angiology, 63: 297-301.
36. Park, D.H. and J.W. Ransone, 2003. Effects of submaximal exercise on high-density lipoprotein-cholesterol subfractions. Int. J. Sports Med., 24: 245-251.
37. Held, C., R. Iqbal, S.A. Lear, A. Rosengren, S. Islam, J. Mathew and S. Yusuf, 2012. Physical activity levels, ownership of goods promoting sedentary behaviour and risk of myocardial infarction: Results of the INTERHEART study. Eur. Heart J., 33: 452-466.
38. Jans, M.P., K.I. Proper and V.H. Hildebrandt, 2007. Sedentary behavior in Dutch workers: Differences between occupations and business sectors. Am. J. Prev. Med., 33: 450-454.
39. Mendez-Hernandez, P., Y. Flores, C. Siani, M. Lamure and L.D. Dosamantes-Carrasco *et al*., 2009. Physical activity and risk of metabolic syndrome in an urban Mexican cohort. BMC Public Health, Vol. 9. 10.1186/1471-2458-9-276
40. Choi, B., P. L. Schnall, H. Yang, M. Dobson and P. Landsbergis *et al*., 2010. Sedentary work, low physical job demand and obesity in US workers. Am. J. Ind. Med., 53: 1088-1101.
41. Kim, E. and S.W. Oh, 2012. Gender differences in the association of occupation with metabolic syndrome in Korean adults. Korean J. Obes., 21: 108-114.
42. Ko, K.J., E.H. Kim, U.H. Baek, Z. Gang and S.J. Kang, 2016. The relationship between physical activity levels and metabolic syndrome in male white-collar workers. J. Phys. Ther. Sci., 28: 3041-3046.
43. Statistics South Africa, 2008. Community survey, 2007: Basic results: Municipalities. Statistical Release P0301.1, Statistics South Africa, Pretoria, South Africa. https://www.statssa.gov.za/publications/P03011/P030112007.pdf
44. Pescatello, L.S., R. Arena, D. Riebe and P.D. Thompson, 2014. ACSM's Guidelines for Exercise Testing and Prescription. 9th Edn., Wolters Kluwer/Lippincott Williams & Wilkins, Philadelphia, USA., ISBN-13: 9781609139551, Pages: 456.
45. NIH., 1998. Clinical guidelines on the identification, evaluation and treatment of overweight and obesity in adults-the evidence report. Obes. Res., 6: 51S-209S.
46. Kahn, H.S. and K.M. Bullard, 2017. Indicators of abdominal size relative to height associated with sex, age, socioeconomic position and ancestry among US adults. PLoS ONE, Vol. 12. 10.1371/journal.pone.0172245
47. Belloc, N.B. and L. Breslow, 1972. Relationship of physical health status and health practices. Prev. Med., 1: 409-421.
48. Sharkey, B.J., 1997. Physiology of Fitness. 3rd Edn., Human Kinetics Books, Champaign, IL., USA., ISBN-13: 9780873222679, Pages: 432.
49. Alberti, K.G.M., P. Zimmet and J. Shaw, 2005. The metabolic syndrome-a new worldwide definition. Lancet, 366: 1059-1062.
50. Grundy, S.M., J.I. Cleeman, S.R. Daniels, K.A. Donato and R.H. Eckel *et al*., 2005. Diagnosis and management of the metabolic syndrome: An American Heart Association/National Heart, Lung and Blood Institute Scientific statement. Circulation, 112: 2735-2752.
51. Saloojee, S., J.K. Burns and A.A. Motala, 2016. Metabolic syndrome in South African patients with severe mental illness: Prevalence and associated risk factors. PLoS ONE, Vol. 11. 10.1371/journal.pone.0149209
52. Srisurapanont, M., S. Likhitsathian, V. Boonyanaruthee, C. Charnsilp and N. Jarusuraisin, 2007. Metabolic syndrome in Thai schizophrenic patients: A naturalistic one-year follow-up study. BMC Psychiatry, Vol. 7. 10.1186/1471-244X-7-14
53. Xi, B., D. He, Y. Hu and D. Zhou, 2013. Prevalence of metabolic syndrome and its influencing factors among the Chinese adults: The China Health and Nutrition Survey in 2009. Prev. Med., 57: 867-871.

54. Alavi, S.S., J. Makarem, R. Mehrdad and M. Abbasi, 2015. Metabolic syndrome: A common problem among office workers. Int. J. Occup. Environ. Med., 6: 34-40.
55. Zhou, H.C., Y.X. Lai, Z.Y. Shan, W.P. Jia and W.Y. Yang *et al*., 2014. Effectiveness of different waist circumference cut-off values in predicting metabolic syndrome prevalence and risk factors in adults in China. Biomed. Environ. Sci., 27: 325-334.
56. Barengo, N.C., G. Hu, T.A. Lakka, H. Pekkarinen, A. Nissinen and J. Tuomilehto, 2004. Low physical activity as a predictor for total and cardiovascular disease mortality in middle-aged men and women in Finland. Eur. Heart J., 25: 2204-2211.
57. Groeneveld, I.F., K.I. Proper, A.J. van der Beek, V.H. Hildebrandt and W. van Mechelen, 2010. Lifestyle-focused interventions at the workplace to reduce the risk of cardiovascular disease-a systematic review. Scand. J. Work Environ. Health, 36: 202-215.
58. Kohli, P. and P. Greenland, 2006. Role of the metabolic syndrome in risk assessment for coronary heart disease. J. Am. Med. Assoc., 295: 819-821.
59. Kruger, M.J. and T.A. Nell, 2017. The prevalence of the metabolic syndrome in a farm worker community in the Boland district, South Africa. BMC Public Health, Vol. 17. 10.1186/s12889-016-3973-1.
60. Rohde, J.F., L. Angquist, S.C. Larsen, J.S. Tolstrup and L.L.N. Husemoen *et al*., 2017. Alcohol consumption and its interaction with adiposity-associated genetic variants in relation to subsequent changes in waist circumference and body weight. Nutr. J., Vol. 16. 10.1186/s12937-017-0274-1
61. Beulens, J.W., R.M. van Beers, R.P. Stolk, G. Schaafsma and H.F. Hendriks, 2006. The effect of moderate alcohol consumption on fat distribution and adipocytokines. Obesity, 14: 60-66.
62. Roerecke, M., J. Kaczorowski, S.W. Tobe, G. Gmel, O.S. Hasan and J. Rehm, 2017. The effect of a reduction in alcohol consumption on blood pressure: A systematic review and meta-analysis. Lancet Public Health, 2: e108-e120.
63. Chiolero, A., D. Faeh, F. Paccaud and J. Cornuz, 2008. Consequences of smoking for body weight, body fat distribution and insulin resistance. Am. J. Clin. Nutr., 87: 801-809.
64. Balhara, Y.P.S., 2012. Tobacco and metabolic syndrome. Indian J. Endocrinol. Metab., 16: 81-87.