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Obstructive sleep apnea and associated factors among hypertensive patients attending a tertiary cardiac center in Tanzania: a comparative cross-sectional study

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Abstract

Background: There is mounting evidence for a reciprocal yet bidirectional association between sleep-disordered breathing and hypertension. Obstructive sleep apnea (OSA), a common cause of systemic hypertension is an independent risk factor for hypertension-related cardiovascular morbidity and mortality. In this comparative hospital-based cross-sectional study, we sought to explore the burden of obstructive sleep apnea and its associated risk factors among hypertensive patients attending Jakaya Kikwete Cardiac Institute.

Methodology: A total of 1974 individuals (i.e. 1289 hypertensive and 685 normotensives) were consecutively enrolled in this study. The Berlin questionnaire and Epworth Sleepiness Scale were utilized in the assessment of OSA and excessive daytime sleepiness (EDS) respectively. Logistic regression analyses were employed in the determination of associated factors for OSA.

Results: The mean age was 53.4 years and females constituted the large majority (60.4%) of participants. About three quarters (74.1%) of participants had excess body weight, 11.6% had diabetes, 8.0% had asthma and 18.6% had history of recurrent nasal congestion. Positive family history of snoring was reported by 43.1% of participants and 36.9% had a personal history of snoring. Persons with hypertension displayed a higher frequency (42.1%) of OSA compared to their normotensive counterparts (11.8%), $p < 0.001$. Multivariate logistic regression analyses revealed hypertension (OR 5.1, 95% CI 3.2-8.2, $p < 0.001$), diabetes mellitus (OR 2.2, 95% CI 1.3-3.5, $p < 0.01$), chronic nasal congestion (OR 1.6, 95% CI 1.1-2.5, $p = 0.01$), obesity (OR 2.4, 95% CI 1.8-3.3, $p < 0.001$), increased neck circumference (OR 2.7, 95% CI 1.2-6.4, $p = 0.02$), family history of snoring (OR 5.5, 95% CI 4.0-7.5, $p < 0.001$), and working > 8 h/24 h (OR 0.6, 95% CI 0.4-1.0, $p = 0.03$) to have an independent association for OSA. Furthermore, participants with hypertension displayed superior odds for OSA compared to their normotensive counterparts across all subgroup analyses.

Conclusion: OSA is considerably common among patients with hypertension in a tertiary health care setting in Tanzania. Positive family history of snoring was the strongest associated factor; however, excess body weight proved to be the strongest modifiable risk factor. In view of its pervasiveness, OSA should be an integral part of the medical evaluation in hypertensive individuals.

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Keywords: OSA, Sleep-related breathing disorders, Sleep apnea, Obstructive sleep apnea, Snoring, Hypertension, Elevated blood pressure, High blood pressure, Developing world, Sub Saharan Africa, Dar Es Salaam, Tanzania

Background

There is mounting evidence for a reciprocal yet bidirectional, and a complex however intriguing association between sleep-disordered breathing and hypertension (Kario 2009; Lavie et al. 2000; Calhoun and Harding 2010; Börgel et al. 2004; Logan et al. 2001; Peppard et al. 2000a; Lavie and Hoffstein 2001; Bixler et al. 2000; Young et al. 1997a; Nieto et al. 2000; Marin et al. 2012; Pedrosa et al. 2011; Gonçalves et al. 2007; Hou et al. 2018; Sapiña-Beltrán et al. 2019; Patel et al. 2019; Ahmad et al. 2017; Belyavskiy et al. 2019; Tam et al. 2019). Obstructive sleep apnea (OSA), a common cause of systemic hypertension is associated with poor blood pressure control and resistant hypertension (Kario 2009; Lavie et al. 2000; Calhoun and Harding 2010; Börgel et al. 2004; Logan et al. 2001; Peppard et al. 2000a; Lavie and Hoffstein 2001; Bixler et al. 2000; Young et al. 1997a; Nieto et al. 2000; Marin et al. 2012; Pedrosa et al. 2011; Gonçalves et al. 2007; Hou et al. 2018; Sapiña-Beltrán et al. 2019; Patel et al. 2019; Ahmad et al. 2017; Belyavskiy et al. 2019; Tam et al. 2019). The mechanisms underlying the association between OSA and hypertension have not been well elucidated. Nevertheless, sympathetic nervous system overactivity is considered to be the primary mechanism linking OSA to the development of hypertension. It has been postulated that the intermittent hypoxia (i.e. hypoxemic - apneic episodes) induced by OSA leads to chemoreceptor activation and increased sympathetic outflow causing inflammation, neurohormonal dysregulation and endothelial dysfunction that predisposes to increased carotid intima-media thickness and arterial stiffness inevitably leading to the development of hypertension (Steiropoulos et al. 2010; Zhang and Si 2012; Wolf and Narkiewicz 2017; Jelic et al. 2002; Minoguchi et al. 2005; Jehan et al. 2020; Fava et al. 2014).

Although less than one-tenth of the general adult population is estimated to be affected (Epstein et al. 2009), OSA is known to distress between 30 and 80% of hypertensives and 70 - 90% of the resistant hypertension subgroup (Epstein et al. 2009; Parati et al. 2014; Parati et al. 2012; Somers et al. 2008). Conversely, between 35 and 80% of individuals with OSA have elevated blood pressure (Parati et al. 2012; Worsnop et al. 1998; Durán-Cantolla et al. 2009; Parati et al. 2013). Evidence from epidemiological studies strongly implicate OSA as an independent risk factor for hypertension-related cardiovascular morbidity (i.e. arrhythmias, cerebrovascular disease, ischemic heart disease, large vessel disease and

heart failure) (Somers et al. 2008; Leung and Bradley 2001; Pinto et al. 2016; Gottlieb et al. 2010; Yaggi et al. 2005; Redline et al. 2010; Shahar et al. 2001; Lattimore et al. 2003; Peker et al. 1999; Moore et al. 2000; Shah et al. 2010) and mortality (Yaggi et al. 2005; Young et al. 2008; Marshall et al. 2008; Punjabi et al. 2009). Additionally, OSA is associated with increased incidence of numerous nocturnal cardiovascular events including angina pectoris, myocardial infarction and sudden cardiac death (Gami et al. 2005; Kuniyoshi et al. 2008). Owing to the paucity of data on the association between OSA and hypertension in sub-Saharan Africa (SSA) in general and Tanzania in particular, we conducted this comparative hospital-based cross-sectional study to explore the burden of OSA and its associated factors among hypertensive patients attending Jakaya Kikwete Cardiac Institute (JKCI).

Methods

Study design, recruitment process, and definition of terms

This comparative cross-sectional hospitalized-based study was conducted at JKCI, a tertiary care public teaching hospital in Dar es Salaam, Tanzania between July 2020 and March 2021. A consecutive sampling method was utilized to recruit consented hypertensive outpatients (cases) and normotensive patient escorts (controls) during their scheduled clinic visit. A structured questionnaire bearing questions pertaining to sociodemographic and clinical characteristics, measurement of key vitals (blood pressure, blood sugar, height, weight, and waist and neck circumference) was used during participants' interviews. Moreover, standard tools (i.e. the Berlin questionnaire (Tan et al. 2017) and Epworth sleepiness scale (Drakatos et al. 2015)) were utilized in the assessment of OSA and EDS respectively. According to a study by Tan A and colleagues, the specificity, sensitivity, positive and negative predictive value of the Berlin questionnaire in detecting moderate-to-severe OSA was 77.6, 58.8, 50.6 and 82.9%, respectively (Tan et al. 2017). We defined underweight as BMI < 18.5 kg/m², normal: BMI 18.5-24.9 kg/m², overweight: BMI 25.0-29.9 kg/m² and obese: BMI ≥ 30.0 kg/m² (Centers for Disease Control and Prevention n.d.). Individuals who smoked at least 1 cigarette in the past 6 months were regarded as current smokers, those who last smoked over 6 months or self-reported quitting smoking were considered past smokers and those who never smoked were regarded

as non-smokers. Alcohol drinking was defined as at least a once consumption every week. Hypertension was defined as SBP ≥ 140 mmHg or DBP ≥ 90 mmHg, or use of blood pressure lowering agents (Chobanian et al. 2003). Diabetes was diagnosed using a random blood glucose (RBG) ≥ 11.1 mmol/L and/or fasting blood glucose (FBG) ≥ 7 mmol/L or use of glucose-lowering agents (American Diabetes Association 2015).

Statistical analysis

All statistical analyses utilized STATA v11.0 software. Summaries of continuous variables are presented as means (\pm SD) and categorical variables are presented as frequencies (percentages). Pearson Chi square and Student's T-test were used in comparison of categorical and continuous variables respectively. Logistic regression analyses were used to assess for factors associated with OSA. Stepwise and forward selection procedure was used to add and assess the statistically significant variables in the multivariate regression model. The multivariate model was fitted with baseline covariates associated with OSA by bivariate analysis at the <0.05 significance level. Furthermore, subgroup analyses to determine the odds for OSA by hypertension status was performed and the findings are presented graphically in a forest plot. Odd ratios with 95% confidence intervals and p -values are reported. All tests were 2-sided and $p < 0.05$ was used to indicate a statistical significance.

Results

Study population characteristics

A total of 1974 individuals (i.e. 1289 hypertensive and 685 normotensives) were enrolled in this study. Table 1 displays the sociodemographic and clinical characteristics of study participants. The mean age was 53.4 years and 63.8% of participants were aged 60 years or less. Females constituted the large majority (60.4%) of participants. 54.0% of participants had attained primary school as their highest level of education and 67.9% were in marriage. Over 80% of participants dwelled in urban areas, 63.3% had a regular income generating activity and 26.4% worked at least 8 h a day. Over one-sixth (15.9%) had a positive smoking history and 10% were current alcohol consumers. Nearly three quarters (74.1%) of participants had excess body weight, 11.6% had diabetes, 8.0% had asthma and 18.6% had history of recurrent nasal congestion. Positive family history of snoring was reported by 43.1% of participants and 36.9% had a personal history of snoring. Surprisingly, none of the participants in this study was aware of OSA and its potential in causing or worsening CVDs and other chronic conditions.

Prevalence and correlates of OSA

Overall, 624 (31.6%) of all participants were categorized as having high-risk for OSA. Persons with hypertension displayed a higher frequency (42.1%) of suffering from OSA compared to their normotensive counterparts (11.8%), $p < 0.001$. Furthermore, the prevalence of high-risk for OSA was similar among hypertensives regardless of their BP range i.e. 41.1% in SBP < 140 , 43.2% in SBP 140-159 and 42.4% in SBP ≥ 160 . Moreover, individuals with hypertension had a 6.8% prevalence of EDS compared to 5.6% among controls, $p = 0.3$, Table 2. During bivariate analyses, participants with high-risk for OSA were older (57.9 vs 51.3, $p < 0.001$) and a positive linear correlation between age and OSA until the age group 60-70 years was observed i.e. < 40 years, 13.4%; 41-50 years, 29.0%; 51-60 years, 36.7%; 61-70 years, 42.9%; and > 70 years, 36.3%. Moreover, participants with high-risk for OSA had a higher comorbidity history [hypertension (87.0% vs 55.3%, $p < 0.001$), diabetes (18.3% vs 8.4%, $p < 0.001$), stroke (7.2% vs 5.0%, $p = 0.05$) and recurrent nasal congestion (25.8% vs 15.3%, $p < 0.001$)], and a higher frequency of known risk factors i.e. positive smoking history (18.3% vs 14.7%, $p = 0.04$), increased body weight (88.9% vs 67.2%, $p < 0.001$), increased neck circumference (88.6% vs 72.3%, $p < 0.001$), post-menopause (83.5% vs 59.8%, $p < 0.001$), positive family (70.2% vs 30.6%, $p < 0.001$) and personal history of snoring (99.7% vs 7.9%, $p < 0.001$), and a higher ESS score (42.8% vs 27.6%, $p < 0.001$); Table 3. Males and females displayed similar odds of suffering from OSA (i.e. 31.7% vs 31.5%, $p = 0.9$).

In a logistic regression model of 16 characteristics, 7 factors i.e. hypertension (OR 5.1, 95% CI 3.2-8.2, $p < 0.001$), diabetes mellitus (OR 2.2, 95% CI 1.3-3.5, $p < 0.01$), chronic nasal congestion (OR 1.6, 95% CI 1.1-2.5, $p = 0.01$), obesity (OR 2.4, 95% CI 1.8-3.3, $p < 0.001$), increased neck circumference (OR 2.7, 95% CI 1.2-6.4, $p = 0.02$), family history of snoring (OR 5.5, 95% CI 4.0-7.5, $p < 0.001$), and working > 8 h/24h (OR 0.6, 95% CI 0.4-1.0, $p = 0.03$) were found to have an independent association of suffering from OSA, Table 4. Furthermore, as displayed in Fig. 1, participants with hypertension had superior odds for suffering from OSA compared to their normotensive counterparts across all subgroup analyses. For instance, among individuals with BMI ≥ 25 those with hypertension displayed a 4-fold chance of having a higher risk of suffering from OSA compared to normotensive persons, OR 4.0, 95% CI 3.0-5.5, $p < 0.001$. Similarly, among participants with a positive family history of snoring, those with hypertension had a 7-fold likelihood of having a higher risk of suffering from OSA compared to their counterparts with negative history of hypertension, OR 7.1, 95% CI 5.1-10.1, $p < 0.001$. Nevertheless, participants with diabetes displayed similar odds of

Table 1 Sociodemographic characteristics of study participants by hypertension status

Characteristic	ALL N = 1974	Hypertensive n = 1289	Normotensive n = 685	p-value
Age (Mean, SD)	53.4 (15.0)	59.8 (11.8)	41.3 (13.0)	< 0.001
Range	18-98	18-98	18-83	
Age group				
> 60	714 (36.2%)	653 (50.7%)	61 (8.9%)	
≤ 60	1260 (63.8%)	636 (49.3%)	624 (91.1%)	< 0.001
Sex				
Male	782 (39.6%)	483 (37.5%)	299 (43.7%)	
Female	1192 (60.4%)	806 (62.5%)	386 (56.4%)	< 0.01
Education				
No Formal	117 (05.9%)	100 (07.8%)	17 (02.5%)	< 0.001
Primary	950 (48.1%)	643 (49.9%)	307 (44.8%)	0.03
Secondary	513 (26.0%)	318 (24.6%)	195 (28.5%)	0.06
University	394 (20.0%)	228 (17.7%)	166 (24.2%)	< 0.001
Marital status				
Single	192 (09.7%)	48 (03.7%)	144 (21.0%)	< 0.001
Married	1341 (67.9%)	873 (67.7%)	468 (68.3%)	0.79
Divorced	128 (06.5%)	82 (06.4%)	46 (06.7%)	0.80
Widowed	313 (15.9%)	286 (22.2%)	27 (04.0%)	< 0.001
Occupation				
Jobless	371 (18.8%)	253 (19.6%)	118 (17.2%)	0.19
Self-employed	888 (45.0%)	487 (37.8%)	401 (58.5%)	< 0.001
Employed	362 (18.3%)	219 (17.0%)	143 (20.9%)	0.03
Retired	353 (17.9%)	330 (25.6%)	23 (03.4%)	< 0.001
Work duration (hours)				
Mean (SD)	6.2 (3.8)	5.4 (3.5)	7.7 (3.9)	< 0.001
> 8 h/day	521 (26.4%)	256 (19.9%)	265 (38.7%)	< 0.001
Residence				
Urban	1618 (82.0%)	1030 (79.9%)	588 (85.8%)	
Rural	356 (18.0%)	259 (20.1%)	97 (14.2%)	< 0.01
Personal Disease History (% Yes)				
Diabetes	228 (11.6%)	211 (16.4%)	17 (02.5%)	< 0.001
Asthma	158 (08.0%)	107 (08.3%)	51 (07.5%)	0.53
Stroke	113 (05.7%)	103 (08.0%)	10 (01.5%)	< 0.001
Recurrent nocturnal nasal congestion	367 (18.6%)	270 (21.0%)	97 (14.2%)	< 0.001
Smoking status				
Ever smoker	313 (15.9%)	284 (14.3%)	129 (18.8%)	
Never	1661 (84.1%)	1105 (85.7%)	556 (81.2%)	< 0.01
Alcohol intake (current)				
Yes	197 (10.0%)	70 (05.4%)	127 (18.5%)	
No	1777 (90.0%)	1219 (94.6%)	558 (81.5%)	< 0.001
Body Mass Index (mean, SD)	29.1 (6.2)	30.3 (6.3)	26.9 (5.5)	< 0.001
BMI categories				
Underweight	34 (01.7%)	11 (0.9%)	23 (03.4%)	< 0.001
Normal	478 (24.2%)	225 (17.4%)	253 (36.9%)	< 0.001
Overweight	680 (34.5%)	447 (34.7%)	233 (34.0%)	0.76
Obese	782 (39.6%)	606 (47.0%)	176 (25.7%)	< 0.001
Waist circumference (mean[cm], SD)	98.1 (14.0)	101.0 (13.4)	92.8 (13.4)	< 0.001
Men > 90 cm	486 (62.1%)	357 (73.9%)	129 (43.1%)	< 0.001
Women > 80 cm	1089 (91.4%)	766 (95.0%)	323 (83.7%)	< 0.001

Table 1 (continued)

Characteristic	ALL N = 1974	Hypertensive n = 1289	Normotensive n = 685	p-value
Neck circumference (mean[cm], SD)	36.8 (3.5)	37.2 (3.4)	35.9 (3.6)	< 0.001
Men > 37 cm	434 (55.5%)	314 (65.0%)	120 (40.1%)	< 0.001
Women > 31 cm	1095 (91.9%)	767 (95.2%)	328 (85.0%)	< 0.001
Family history of snoring				
Positive	851 (43.1%)	566 (43.9%)	285 (41.6%)	0.33
Negative	982 (49.8%)	617 (47.9%)	365 (53.3%)	0.02
Don't Know	141 (07.1%)	106 (08.2%)	35 (05.1%)	0.01
Personal history of snoring				
Positive	729 (36.9%)	564 (43.8%)	165 (24.0%)	< 0.001
Negative	1156 (58.6%)	659 (51.1%)	497 (72.6%)	< 0.001
Don't Know	89 (04.5%)	66 (05.1%)	23 (03.4%)	0.08
OSA awareness				
Yes	0 (0%)	0 (0%)	0 (0%)	1.0
No	1974 (100%)	1289 (100%)	685 (100%)	1.0

Table 2 Prevalence and pattern of Excessive Daytime Sleepiness by hypertension status

EDS	Frequency (%)		p - value
	Hypertensive	Normotensive	
Unlikely	635 (49.3%)	373 (54.5%)	0.03
Average	210 (16.3%)	116 (16.9%)	0.7
Excessive situational	356 (27.6%)	158 (23.1%)	0.03
Excessively sleepy	88 (06.8%)	38 (05.6%)	0.3

suffering from OSA regardless of their hypertension status, OR 1.9, 95%CI 0.6-6.6, $p = 0.21$.

Discussion

Over the past five decades, OSA, a potentially treatable disorder that is characterized by cyclic intermittent hypoxia and the disruption of sleep architecture has been increasingly recognized as a widespread syndrome causing significant population health burden. Despite its ubiquity and potential to either cause or modify the course of other chronic disorders, OSA continues to be underdiagnosed and undertreated worldwide (Punjabi 2008; Young et al. 1997b). With over two-fifth of hypertensives having high-risk of suffering from OSA, this present study echoes findings from previous studies (Kario 2009; Lavie et al. 2000; Calhoun and Harding 2010; Börgel et al. 2004; Logan et al. 2001; Peppard et al. 2000a; Lavie and Hoffstein 2001; Bixler et al. 2000; Young et al. 1997a; Nieto et al. 2000; Marin et al. 2012; Pedrosa et al. 2011; Gonçalves et al. 2007; Hou et al. 2018; Sapiña-Beltrán et al. 2019; Patel et al.

2019; Ahmad et al. 2017; Belyavskiy et al. 2019; Tam et al. 2019; Steiropoulos et al. 2010; Zhang and Si 2012; Wolf and Narkiewicz 2017; Jelic et al. 2002; Minoguchi et al. 2005; Jehan et al. 2020; Fava et al. 2014; Epstein et al. 2009; Parati et al. 2014; Parati et al. 2012; Somers et al. 2008) that OSA is highly prevalent among hypertensive individuals. In unison with the literature (Hedner et al. 2006; Sia et al. 2017; Redline et al. 2014; Rezaie and Khaledi-Paveh 2018), this study has revealed critically low awareness regarding OSA and its associated health-related consequences. Amid the rapid rising obesity, hypertension and diabetes rates, it is pivotal to intensify the ongoing health education campaigns to increase awareness so that they coincide with the temporal trends in public knowledge of OSA amongst others.

Moreover, a positive linear correlation between age and OSA until the age group 60-70 years was observed in this present study. Such findings are literally identical to the Sleep Heart Health Study which demonstrated a simple, positive linear correlation between age and OSA until the age of about 65 years (Young et al. 2002). Furthermore, this linear trend between OSA and age until about the age 65 then levelling off or even decreasing has been reported by a couple of other recent studies (Huang et al. 2018; Marshall et al. 2014; Fietze et al. 2019). We observed similar EDS rates among hypertensives and normotensives. Previous studies have revealed conflicting results with some (Goldstein et al. 2004; Mbatchou Ngahane et al. 2015) showing independent association between EDS and hypertension while others did not (Tam et al. 2019; Pefura-Yone et al. 2020; Martynowicz et al. 2017). As witnessed in this study, such

Table 3 Sociodemographic and Clinical characteristics comparison by OSA status

Characteristic	High-risk OSA n = 624	Low-risk OSA n = 1350	p - value
Age (Mean, SD)	57.9 (12.3)	51.3 (15.7)	< 0.001
n			
< 40 years ^c	59 (13.4%)		–
442			
41-50	98 (29.0%)		< 0.001
338			
51-60	176 (36.7%)		< 0.001
480			
61-70	206 (42.9%)		< 0.001
480			
> 70 years	85 (36.3%)		< 0.001
234			
Female sex	376 (60.3%)	816 (60.4%)	1.0
≤ Primary education	346 (55.5%)	721 (53.4%)	0.38
Married	439 (70.4%)	902 (66.8%)	0.11
Work duration > 8 h/day	135 (21.6%)	386 (28.6%)	0.001
Urban residency	505 (80.9%)	1113 (82.4%)	0.42
Comorbidities history			
Hypertension	543 (87.0%)	746 (55.3%)	< 0.001
Diabetes	114 (18.3%)	114 (08.4%)	< 0.001
Asthma	48 (07.7%)	110 (08.2%)	0.70
Stroke	45 (07.2%)	68 (05.0%)	0.05
Recurrent nocturnal nasal congestion	161 (25.8%)	206 (15.3%)	< 0.001
Menopause ^a	314 (83.5%)	488 (59.8%)	< 0.001
Ever smoker	114 (18.3%)	199 (14.7%)	0.04
Current drinker	43 (06.9%)	154 (11.4%)	0.002
Measures of obesity			
BMI ≥ 25	555 (88.9%)	907 (67.2%)	< 0.001
Neck > 37 cm M/31 cm F	553 (88.6%)	976 (72.3%)	< 0.001
Waist > 90 cm M/80 cm F	572 (91.7%)	1003 (74.3%)	< 0.001
Snoring history			
Positive family	438 (70.2%)	413 (30.6%)	< 0.001
Positive personal	622 (99.7%)	107 (07.9%)	< 0.001
SBP ≥ 140 and/or DBP ≥ 90 ^b	365 (67.2%)	482 (64.6%)	0.26
SBP < 140 ^{bc}	207 (41.1%)		–
504			
SBP 140-159 ^b	183 (43.2%)		0.51
424			
SBP ≥ 160 ^b	153 (42.4%)		0.70
361			
ESS score ≥ 10	267 (42.8%)	373 (27.6%)	< 0.001

^a assessed in women, n = 1192; ^b assessed in hypertensives, n = 1289; ^c reference group

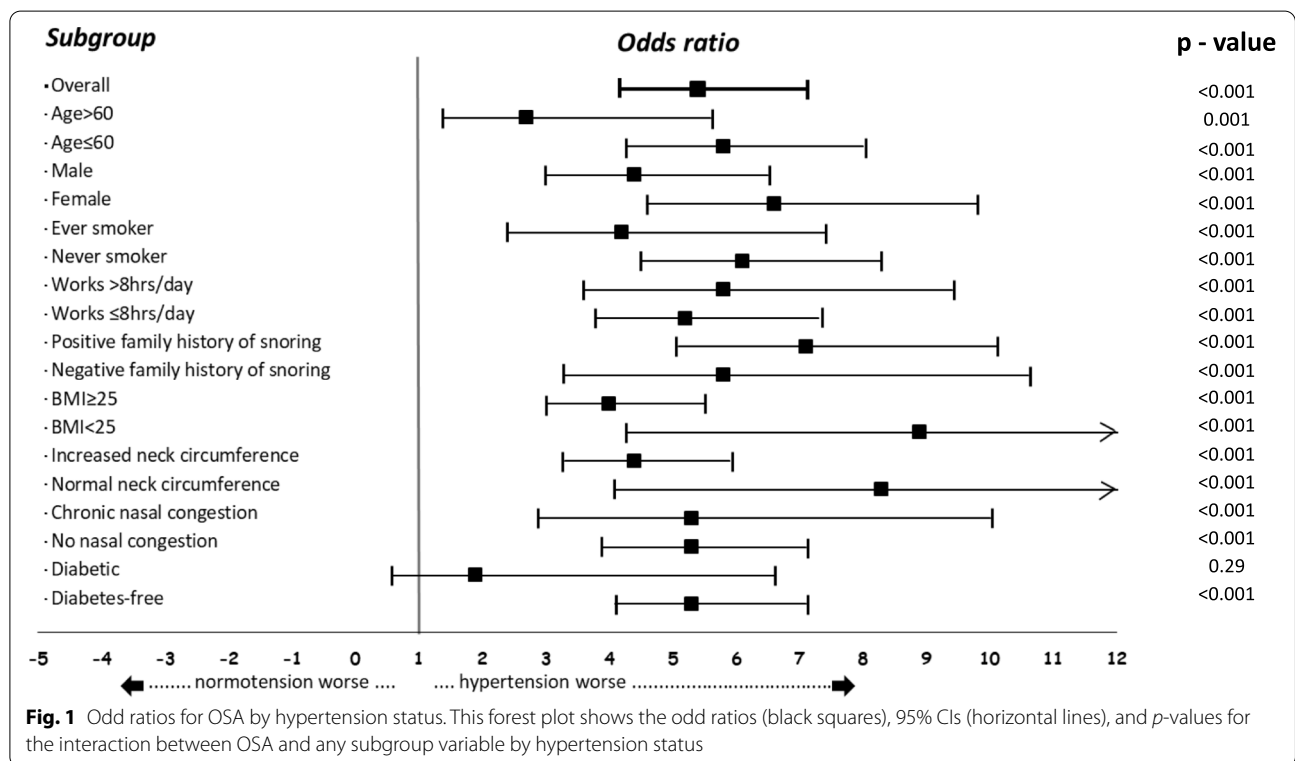
controversy can largely be explained by a high prevalence of overweight and obesity which independently increases the risk of EDS (Mokhber et al. 2016; Panossian and Veasey 2012; Hayley et al. 2014).

Nonetheless, with a 2-fold likelihood of suffering from OSA among obese individuals, our findings are in consonance with numerous other studies which have revealed

excessive body weight as a potential factor for the development and progression of OSA (Young et al. 2002; Durán et al. 2001; Resta et al. 2001; Wolk and Somers 2006; Pppard et al. 2000b; Romero-Corral et al. 2010; Young et al. 1993; Bixler et al. 1998; Ip et al. 2004; Ip et al. 2001). Furthermore, as it was vivid in this study, other anthropometric measurements including neck and waist circumference

Table 4 Logistic regression analyses for factors associated with OSA

Characteristic	Comparative	OR	95% CI	p-value	Adj.OR	95% CI	p-value
Age > 60	Age ≤ 60	1.9	1.6-2.3	< 0.001	1.2	0.8-1.7	0.32
Male	Female	1.0	0.8-1.2	0.94	–	–	–
Diabetes	Diabetes-free	2.4	1.8-3.2	< 0.001	2.2	1.3-3.5	< 0.01
Asthmatic	Asthma-free	0.9	0.7-1.3	0.73	–	–	–
History of stroke	Stroke-free	1.5	1.0-2.2	0.05	0.8	0.4-1.6	0.57
Chronic nasal congestion	No congestion	1.9	1.5-2.4	< 0.001	1.6	1.1-2.5	0.01
Ever smoker	Never smoker	1.3	1.0-1.7	0.05	0.8	0.4-1.8	0.63
BMI ≥ 30	BMI < 30	3.7	3.0-4.5	< 0.001	2.4	1.8-3.3	< 0.001
Neck > 37 cm M/31 cm F	Normal Neck	3.0	2.3-3.9	< 0.001	2.7	1.2-6.4	0.02
Family history of snoring	Negative history	6.1	4.9-7.6	< 0.001	5.5	4.0-7.5	< 0.001
Uncontrolled BP	BP < 140/90	0.9	0.7-1.1	0.33	–	–	–
ESS score ≥ 10	ESS score < 10	2.0	1.6-2.4	< 0.001	1.3	0.9-1.8	0.12
Hypertensive	Negative history	5.4	4.2-7.0	< 0.001	5.1	3.2-8.2	< 0.001
Alcohol intake	Non drinker	0.6	0.4-0.8	0.002	1.4	0.7-3.1	0.34
Post-menopausal	Pre-menopausal	3.4	2.5-4.6	< 0.001	1.2	0.8-1.9	0.36
Works > 8 h/day	works ≤ 8 h/day	0.7	0.6-0.9	0.001	0.6	0.4-1.0	0.03



have revealed a monotonic relationship with OSA similar to previous studies (Young et al. 2002; Stradling and Crosby 1991; Ferini-Strambi et al. 1994; Davies et al. 1992; Grunstein et al. 1993). Moreover, it is postulated that each unit increase in BMI is associated with a 14% increased risk of developing OSA and the odds of moderate-severe

OSA increases 6-fold for every 10% weight gain (Pepard et al. 2000b). Conversely, a 10-15% reduction in body weight has been shown to reduce OSA severity by 50% (Nousseir 2019). Our findings similar to majority of previous studies imply that excessive body weight is the strongest modifiable risk factor for OSA.

Our association analysis furthermore disclosed a 2-fold increase in OSA likelihood among diabetes type 2 patients compared to their diabetes-free counterparts. Several cross-sectional and longitudinal studies have demonstrated an independent association between OSA and incident type 2 diabetes (Appleton et al. 2015; Kendzerska et al. 2014; Marshall et al. 2009; Nagayoshi et al. 2016; Botros et al. 2009; Celen et al. 2010; Lindberg et al. 2012) as well as with insulin resistance but diabetes-free persons (Punjabi et al. 2002; Punjabi and Beamer 2009; Iftikhar et al. 2015; Ip et al. 2002). Furthermore, a positive family history of snoring instigated an over 5-fold increase in OSA likelihood and was found to be the strongest predictor of OSA in this study. Similarly, a Cleveland Family Study, the largest familial study investigating OSA revealed a near 2-fold risk among relatives of OSA compared to their control neighbors (Redline et al. 1995). Furthermore, studies involving monozygotic twins and siblings/children of persons with OSA have shown an up-to 50% increased odds of developing OSA compared to the general population (Ferini-Strambi et al. 1995; Friberg et al. 2009; Lundkvist et al. 2012; Szily et al. 2019). Additionally, numerous genetic studies (Palmer et al. 2003; Patel et al. 2007; Khalyfa et al. 2008; Gozal et al. 2007; Kalra et al. 2008; Farias Tempaku et al. 2020; Maierean et al. 2021; Kerz et al. 2021; Patel et al. 2012) have identified several novel genetic loci associated with a sleep apnea phenotype suggesting around two-fifth (Casale et al. 2009; Yue et al. 2008; Yue et al. 2005) of the OSA variance is attributable to genetic factors.

Strengths and limitations

The strengths of this study include (i) a sufficiently large sample to estimate the prevalence of OSA and conduct analyses stratified according to potential effect modifiers, (ii) the use of rigorous and standardized tools for data collection and utilization of qualified and competent personnel in all measurements, and (iii) presence of a comparative group in this study made the demonstration of outcome measure risk more robust. Nonetheless, this study is not short of limitations. The cross-sectional nature and convenience sampling method technique utilized in this study cannot preclude bias and limits both causality exploration and generalizability of findings. Prospective studies on the longitudinal association between OSA and hypertension incidence will help elucidate the true nature and magnitude of this intriguing association. Lastly, the gold standard for the diagnosis of OSA is an overnight polysomnography; however, because of its limited availability, complex technical support, and high cost, this study relied on a self-reported but validated assessment modality.

Conclusion

In conclusion; OSA, a largely modifiable CVD risk factor is considerably common among hypertensives in a tertiary health care setting in Tanzania. Positive family history of OSA was found to be the strongest associated factor; however, excess body weight proved to be the strongest modifiable risk factor. In view of its pervasiveness, OSA ought to be an integral part of the medical evaluation in hypertensive individuals. Furthermore, a multipronged approach to curb the escalating obesity epidemic is paramount in the battle against sleep-related breathing disorders.

Abbreviations

95% CI: 95% Confidence Interval; BMI: Body mass index; BP: Blood pressure; CVD: Cardiovascular disease; DBP: Diastolic blood pressure; EDS: Excessive daytime sleepiness; FBG: Fasting blood glucose; JKCI: Jakaya Kikwete Cardiac Institute; OR: Odd Ratio; OSA: Obstructive sleep apnea; RBG: Random blood glucose; SSA: Sub Saharan Africa; SBP: Systolic blood pressure.

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Authors' contributions

PP and LRM conceived the study. MK, JM, NM, and HJS conducted all the interviews, as well as anthropometric and blood pressure measurements. ZM entered all the data. HM, SB, SW, and MJ participated in patient management including counseling. PP performed all the data cleaning and analysis. The corresponding author (PP) wrote the first draft of the manuscript, and other authors contributed to and approved it. All authors made the decision to submit the manuscript for publication. All authors undertake responsibility for the accuracy and integrity of the analysis.

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Availability of data and materials

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study protocol was submitted to, and approved by the Ethical Committee, of the Jakaya Kikwete Cardiac Institute. Written informed consent was obtained from all study participants. This research was conducted in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors have no conflict of interest to declare.

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