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Obesity and Cardiovascular Risk Factors in a Pentecostal Population in Kumasi-Ghana

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The purpose of this study was to examine the risk associations between indices of obesity [Body Mass Index (BMI), Waist Circumference (WC), Waist-to-Hip Ratio (WHR) and Waist-to-Height Ratio (WHtR)], cardiovascular risk factors [plasma glucose and cholesterol and blood pressure] and morbidity conditions (Type 2 diabetes mellitus, hypertension and dyslipidemia) among Penteco-Charismatic Ghanaians. Three hundred and eighty three Penteco-Charismatic Ghanaian subjects (18-85 years of age) were recruited from Pentecost Church, Santasi (101), Assembly of God Bantama (192) and, Assembly of God, Old Tafo (90) in Kumasi, Ghana. The mean BMI were 25.72±5.97 kg m^{-2}, 22.61±3.48 and 27.10±6.33 kg m^{-2} for the study population, male and female subjects, respectively. The mean WC measurement for the subjects was 90.21±12.29 cm and 85.91±8.77 and 92.10±13.13 cm in male and females, respectively. There were increasing trends between indices of obesity and the severity of cardiovascular risk factors and the prevalence of morbidity conditions (all p-values for trend <0.05). Patients with a greater number of comorbidities also had higher BMI, WC, WHR and WHtR measurements (all p-values for the trend were <0.05 with adjustment for age and gender). Despite Penteco-Charismatic Ghanaian subjects being less obese than subjects from Caucasians countries, the intimate relationships among obesity, cardiovascular risk factors and morbidity conditions remain. This study support using lower BMI and WC levels to define obesity and its associated health risks rather than using the criteria established for Caucasians who generally have larger body frames. Obesity is becoming increasingly common among Ghanaian adults. There is, therefore, the need for broad-based programs that facilitate healthy eating and activity patterns for all age groups. Health professionals should incorporate measurement of BMI and WHR into the routine examinations of patients to enhance their evaluation of the health status of their patients.

Key words: Obesity, comorbidities, pentecostal, hypertension

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INTRODUCTION

It is estimated that over 115 million people suffer from obesity related health conditions in the developing nations (Walker *et al*., 2001; McLellan, 2002; WHO, 2004). An increase in body weight with an increase in age was an uncommon occurrence in Sub Saharan African populations just over a little more than a generation ago (Wilding, 2007). However, recent studies have shown that particularly in the urban environment the prevalence of obesity and obesity linked illnesses are increasing (Holdsworth *et al*., 2004). The aetiology of obesity in all populations is complex and the causes include genetics, diet, activity level and cultural norms as a sign of wealth and prosperity (Walker *et al*., 2001).

Obesity has been associated with an increased incidence of several cancers (Vatten and Kvinnsland, 1990) and a higher prevalence of hypertension (Barrett-Connor and Khaw, 1985), hyperlipidemia (Walker, 2003) and diabetes mellitus (Bonham and Brock, 1985). The distribution of fat in overweight people has important metabolic consequences (Roncari, 1988). Abdominal fat, measured by the ratio of waist to hip circumferences (WHR), is the most commonly used index of central fat distribution (Campaigne, 1990), its use may be beneficial in routine monitoring and assessment of overweight patients who may be at increased risk of CAD. Increased WHR has been associated with increased incidence of ischaemic heart disease, stroke and death (Folsom *et al*., 1990) and a higher prevalence of hypertension (Selby *et al*., 1989), hyperlipidemia (Seidell *et al*., 1990) and diabetes (Bonham and Brock, 1985). There is a general agreement that increased health risks are associated with a WHR greater than 0.8 in women and in men 0.9 or 1.0 (Bjorntorp, 1985).

Most, religious doctrines proscribe foods from animal sources permanently or for particular periods. There are several religions, such as Islam, Hinduism, Buddhism, Judaism, Seventh-Day-Adventism and Orthodox Christianity that have often been studied regarding their relation to health (Shatenstein and Ghadirian, 1998; Temizhan *et al*., 2000; Friedlander *et al*., 1985; Fraser, 1999). However, there is a paucity of data on the Penteco-Charismatic Christian whose doctrine proscribes smoking and alcohol consumption. Regular intermittent fasting and praying is encouraged to enhance spirituality.

Ghana is a tropical country in West Africa with a surface area of 238.533 km^2, an estimated population of 23.1 million, a gross domestic product (GDP) of 7.4 billion US dollars and per capita GDP of 412 US dollars. The Kumasi Metropolitan area has the second largest urban population. In Ghana, no study to date has focused on the impact of Penteco-Charismatic Christian intermittent short-term religious fasting on Waist-to-hip ratio, FBS, serum cholesterol and obesity. The objectives of this study were therefore to describe the distribution of weight and abdominal obesity among Penteco-Charismatic Christian adults and to determine the association of obesity with other risk factors for cardiovascular disease.

MATERIALS AND METHODS

Subjects: This study was conducted between August and October, 2005. The subjects of this study were recruited from an adult population in Kumasi, Ashanti region, Ghana. Three hundred and eighty three Pentecost-Charismatic Christians worshiping at Pentecost Church, Santasi (101), Assembly of God, Bantama (192) and Assembly of God, Old Tafo (90) were encouraged to participate in this study. All the participants fasted regularly according to the revival schedules of the Penteco-Charismatic Christian Church. The participation of the respondents was voluntary and informed consent was obtained from each of them. Subjects who were on medications that could affect serum cholesterol, Blood Pressure (BP), or carbohydrate metabolism or those who were known diabetics or hypertensives were excluded from the analysis. The study was approved by the local Committee on Human Research Publication and Ethics.

Sample collection and preparation: Venous blood samples were collected after an overnight fast (12-16 h). About 5 mL of venous blood was collected and dispensed into fluoride oxalate tubes and vacutainer® plain tubes for separation into plasma and serum, respectively. This was then taken to the laboratory and centrifuged at 500 g for 15 min within 30 min of sample collection for plasma and serum, respectively. The plasma was then used for the assay of glucose and the serum for cholesterol determination.

Anthropometric variables: Subjects were weighed on a bathroom scale while barefooted and their height was measured with a wall-mounted ruler. BMI was calculated by dividing weight (kg) by height squared (m^2). On the basis of BMI, all subjects were divided into four groups: under weight (BMI<19 kg m^{-2}), normal (BMI between 19 and 24.9 kg m^{-2}), overweight (BMI between 25 and 29.9 kg m^{-2}) and obese (BMI≥30 kg m^{-2}), Waist circumference was measured with a Gulick II springloaded measuring tape (Gay Mills, WI) midway between the inferior angle of the ribs and the suprailiac crest, whereas hip circumference was measured at the outermost points of the greater trochanters. WHR was recorded to the nearest 2 decimal places.

BP was taken by trained personnel using a mercury sphygmomanometer and stethoscope. Measurements were taken from the left upper arm after subjects had been sitting for >5 min in accordance with the recommendation of the American Heart Association (Kirkendall *et al*., 1967). Duplicate measurements were taken with a 5 min rest interval between measurements and the mean value was recorded to the nearest 2.0 mmHg.

RESULTS

Clinical characteristics The baseline clinical and biochemical characteristics of the study participants are shown in Table 1. Approximately 10, 24, 21, 17, 66, 20, 63 and 70% had the following morbidity condition(s): Type II diabetes mellitus, systolic hypertension, diastolic hypertension, dyslipidemic, central obesity-WC, obesity-BMI, obesity-WHR and obesity-WHtR, respectively (Fig. 1).

Comparisons between subjects with different age ranges: With increasing age ranges (Table 2), there were increasingly adverse cardiovascular risk profiles as reflected by high fasting plasma glucose concentration, high blood pressure and high total cholesterol, high BMI, WHR, WHtR. There were also high prevalence of diabetes, dyslipidemia and obesity, Table 3 shows the percentages of individuals with the various conditions.

Comparisons between patients with increasing number of comorbidities: Many of the patients had multiple comorbidities and patients with greater number of comorbidities also had higher BMI and WC levels except for hyperlipidemia where the BMI showed no significant difference (all p-value summary are indicated above the bar after adjustment for age and gender, Fig. 2).

In Fig. 3 many of the patients also had multiple comorbidities and patients with greater number of comorbidities had higher WHR and WHtR levels. However, WHtR does not show any significant difference in patient with type II diabetes and hyperlipidemia.

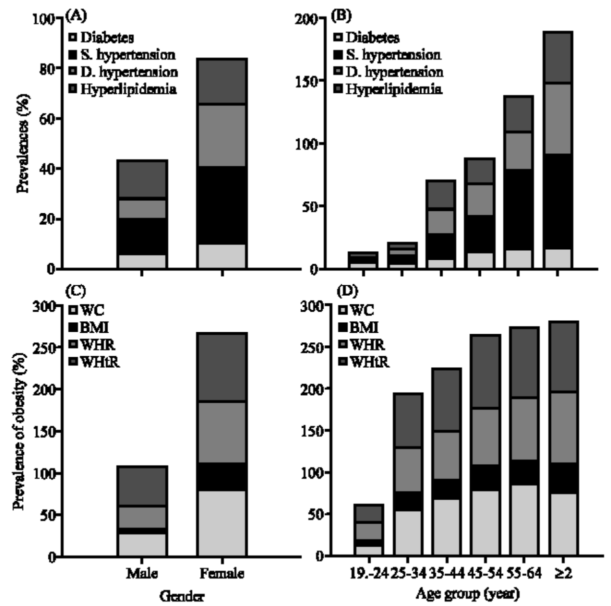

Fig. 1: (A) Prevalence of diabetes, systolic hypertension, diastolic hypertension and hyperlipidemia among male and female subject, (C) prevalence of obesity based on WC, BMI, WHR and WHtR among male and female subjects, (B) Prevalence of diabetes, systolic hypertension, diastolic hypertension and hyperlipidemia among the various age group and (D) prevalence of obesity based on WC, BMI, WHR and WHtR among the various age groups

Table 1: Characteristics of whole study population

Parameters	Whole	Male	Female
Age (years)	41.64±13.40 (383)	38.08±12.04 (117)	43.21±13.69(266)***
Weight (kg)	67.32±13.93 (382)	65.50±10.68 (117)	68.13±15.10 (265)^{ns}
Height (m)	1.62±0.11 (382)	1.70±0.09 (117)	1.59±0.10 (265)***
WC (cm)	90.21±12.29 (382)	85.91±8.77 (117)	92.10±13.13 (265)***
HC (cm)	104.79±13.87 (381)	97.83±12.39 (116)	107.84±13.39 (265)***
BMI (kg m^{-2})	25.72±5.97 (382)	22.61±3.48 (116)	27.10±6.33 (265)***
WHR	0.87±0.10 (381)	0.89±0.14 (116)	0.86±0.08 (265)**
WHtR	55.78±8.60 (382)	50.52±5.14 (117)	58.11±8.80 (265)***
SBP (mmHg)	123.57±20.54 (383)	117.07±15.70 (117)	126.43±21.76 (266)***
DBP (mmHg)	76.19±12.81 (383)	72.86±10.30 (117)	77.66±13.52 (266)***
FBS (mmol L^{-1})	5.00±1.65 (266)	5.04±2.06 (111)	4.98±1.43 (255)^{ns}
TC (mmol L^{-1})	5.00±1.85 (382)	4.67±1.64 (82)	5.12±1.92 (183)^{ns}

The data are presented as Mean±SD, sample size are in parenthesis, WC: Waist Circumference, HC: Hip Circumference, BMI: Body Mass Index, WHR: Waist-to-Hip Ratio, WhtR: Waist-to-Height Ratio, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, FBS: Fasting Blood sugar, TC: Total Serum Cholesterol, ns: Not significant, *p<0.05, **p<0.001 and ***p<0.0001

Table 2: Comparisons of clinical and biochemical parameters, prevalence of morbidity between subjects divided into different ranges of age (years)

	Age group (year)						
Parameters	19-24	25-34	35-44	45-54	55-64	≥65	Total
Sample size (N)	36	88	110	86	37	26	383
Age (years)	21.78±1.79	29.67±2.85	39.66±2.62	48.53±2.59	58.24±2.92	71.65±6.99	41.64±13.40
Weight (kg)	58.33±6.67	65.20±12.04	68.36±14.19	70.86±14.05	70.27±14.79	66.65±18.53	67.32±13.93
Height (cm)	1.63±0.10	1.63±0.11	1.63±0.10	1.63±0.11	1.63±0.10	1.54±0.14	1.62±0.11
WC (cm)	78.28±4.32	86.06±10.51	90.73±11.20	94.13±10.20	97.48±12.08	95.25±19.00	90.21±12.29
HC (cm)	95.89±9.74	103.26±11.25	105.88±13.43	106.61±15.56	109.25±13.59	105.36±17.50	104.79±13.87
BMI (kg m^{-2})	22.08±3.31	25.01±6.12	25.77±6.01	26.84±6.24	26.63±5.36	28.01±6.04	25.72±5.97
WHR	0.82±0.07	0.84±0.07	0.86±0.11	0.90±0.12	0.90±0.10	0.90±0.08	9.87±0.10
WHtR	48.17±4.06	53.23±7.81	55.73±7.88	57.94±7.91	60.11±7.87	61.94±11.49	55.78±8.60
SBP (mmHg)	109.50±10.78	113.77±11.63	121.71±18.35	127.17±18.75	139.14±25.75	150.04±20.62	123.57±20.54
DBP (mmHg)	67.72±7.68	70.84±8.65	76.23±12.79	80.05±12.36	81.41±15.48	85.73±13.98	76.19±12.81
FBS (mmol L^{-1})	4.94±0.75	4.67±0.81	5.01±2.11	5.15±1.61	5.21±1.59	5.30±2.39	5.00±1.65
TC (mmol L^{-1})	4.09±1.07	4.44±1.11	5.06±1.67	5.08±1.99	5.86±2.26	6.63±2.85	5.00±1.85

The data are presented as Mean±SD, sample size are in parenthesis, WC: Waist Circumference, HC: Hip Circumference, BMI: Body Mass Index, WHR: Waist-to-Hip Ratio, WHtR: Waist-to-Height Ratio, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, FBS: Fasting Blood Sugar, TC: Total Serum Cholesterol

Table 3: Percentages of individual with various conditions

Parameters		Whole	Male	Female
Gender	M or F	100.00 (383)	30.55 (117)	69.45 (266)
Age (years)	19-24	9.40 (36)	55.56 (20)	44.44 (16)
	25-34	22.98 (88)	28.41 (25)	71.59 (63)
	35-44	28.72 (110)	32.73 (36)	67.27 (74)
	45-54	22.45 (86)	31.40 (27)	68.60 59)
	55-64	9.66 (37)	16.22 (6)	83.78 (31)
	≥65	6.79 (26)	11.54 (3)	88.46 (23)
WC (cm)	Normal	34.46 (132)	62.88 (83)	37.12 (49)
	Central obesity	65.54 (251)	13.36 (34)	86.64 (217)
BMI (kg m^{-2})	Underweight	6.53 (25)	56.00 (14)	44.00 (11)
	Normal	48.04 (184)	41.85 (77)	58.15 (107)
	Overweight	25.07 (96)	23.96 (23)	76.04 (73)
	Obese	20.37 (78)	3.84 (3)	96.16 (75)
WHR	Normal	37.43 (143)	57.34 (82)	42.66 (61)
	Obese	62.57 (239)	14.23 (34)	85.77 (205)
SBP (mmHg)	Normal	75.98 (291)	35.40 (103)	64.60 (188)
	Hypertension	24.02 (92)	15.21 (14)	84.79 (78)
DBP (mmHg)	Normal	79.37 (304)	34.87 (106)	65.13 (198)
	Hypertension	20.63 (79)	13.92 (11)	86.08 (68)
FBS (mmol L^{-1})	Normal	90.74 (333)	31.23 (104)	68.77 (229)
	Diabetic	9.26 (34)	20.59 (7)	79.41 (27)
Total cholesterol (mmol L^{-1})	Normal	82.98 (234)	32.05 (75)	67.95 (159)
	Hyperlipidaemia	17.02 (48)	27.08 (13)	72.92 (35)
WHtR	Normal	29.77 (114)	55.26 (63)	44.74 (51)
	Obese	70.23 (269)	20.07 (54)	69.93 (215)

The data are presented as Mean±SD, sample size are in parenthesis, WC: Waist Circumference, HC: Hip Circumference, BMI: Body Mass Index, WHR: Waist-to-hip Ratio, WHtR: Waist-to-height Ratio, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, FBS: Fasting Blood Sugar, TC: Total Serum Cholesterol

In Fig. 4 total cholesterol does not show any significant difference in patients with only type II diabetes and only hypertension when compared to the control group. However, there was a significant increase in the level of total cholesterol when the control group was compared to patients with type II diabetes and hypertension ($p<0.05$).

Associations between anthropometric indices and age: In Table 4, the correlation matrix between anthropometric variables, body composition and age is given for men and women separately. Most anthropometric indices were highly correlated to each other in both sexes. The high correlation coefficients observed between BMI, WHR and WHtR in both sexes suggests an interchangeable use of these anthropometric indices. With the exception of percentage Height and HC in women, all anthropometric indices correlated with age.

Associations between anthropometric indices and metabolic risk: In Table 5 partial correlations corrected for age describe the relationships between anthropometric variables and metabolic risk factors for the whole group as well as separately for women and men.

Table 4: Pearson correlation coefficients between anthropometric variables and age for women (lower left-hand side) and men (upper right-hand side)

Parameters	Age	Weight	Height	WC	HC	BMI	WHR	WHtR
Age	-	0.35**	0.52**	0.48**	0.22*	0.52**	0.52**	0.59**
Weight	0.12*	-	0.41**	0.82**	0.62**	0.65**	0.41**	0.67**
Height	-0.10	0.28**	-	0.31**	0.11	0.93**	1.00**	0.77**
WC	0.32**	0.83**	0.13*	-	0.55**	0.53**	0.31**	0.77**
HC	0.10	0.81**	0.17**	0.75**	-	0.34**	0.10	0.40**
BMI	0.14*	0.77**	-0.38**	0.70**	0.65**	-	0.93**	0.90**
WHR	0.40**	0.20**	0.00	0.51**	-0.18**	0.21**	-	0.77**
WHtR	0.33**	0.65**	-0.36**	0.89**	0.63**	0.85**	0.49**	-

*Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed). WC: Waist Circumference, HC: Hip Circumference, BMI: Body Mass Index, WHR: Waist-to-Hip Ratio, WHtR: Waist-to-Height Ratio

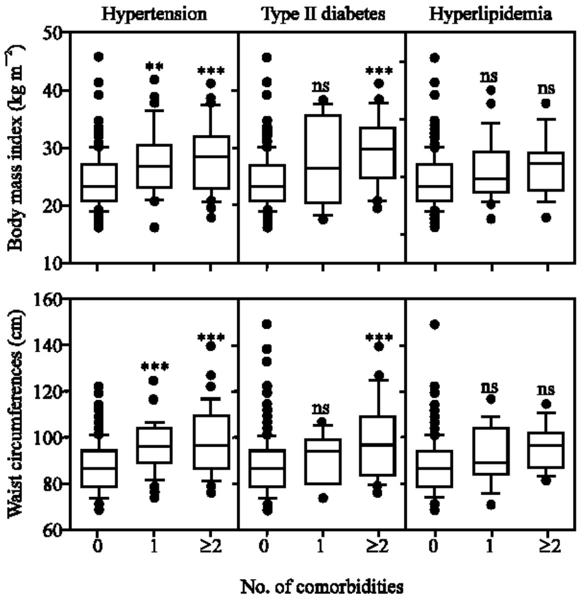

Fig. 2: Comparisons of body mass index and waist circumference between patients with a different number of comorbidities in cohorts of patients with a primary diagnosis of type II diabetics, hypertension and dyslipidaemia. The potential morbidity conditions for diabetic patients included hypertension and dyslipidaemia; those for hypertensives included diabetes mellitus and dyslipidaemia and those for dyslipidaemics included diabetes mellitus and hypertension. The lower and upper margins of the box represent the 25 and 75th percentiles, with the extended arms representing the 10 and 90th percentiles, respectively. The median is shown as the horizontal line within the box. Outlying points are shown individually. All p-values: *<0.05, **<0.001, ***<0.0001 and ns: Not Significant, using polynomial analysis of covariance with adjustment for age and gender

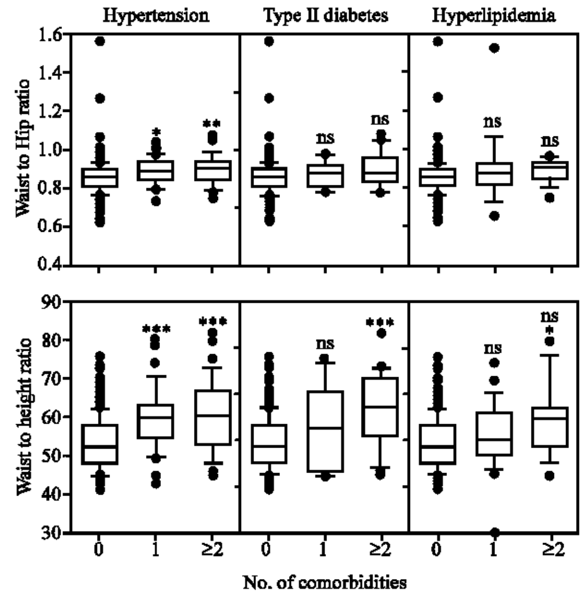

Fig. 3: Comparisons of waist to Hip ratio and waist to height ratio between patients with a different number of comorbidities in cohorts of patients with a primary diagnosis of type II diabetics, hypertension and dyslipidaemia. The potential morbidity conditions for diabetic patients included hypertension and dyslipidaemia; those for hypertensives included diabetes mellitus and dyslipidaemia and those for dyslipidaemics included diabetes mellitus and hypertension. The lower and upper margins of the box represent the 25th and 75th percentiles, with the extended arms representing the 10 and 90th percentiles, respectively. The median is shown as the horizontal line within the box. Outlying points are shown individually. All p-values: *<0.05, **<0.001, ***<0.0001 and ns: Not Significant, using polynomial analysis of covariance with adjustment for age and gender

Table 5: Partial correlation between anthropometric variables and metabolic risk factors after adjustment for age

	WC	BMI	Waist: Hip	Waist: Height
All				
Systolic BP	0.21**	0.19**	0.10	0.20**
Diastolic BP	0.19**	0.21**	0.08	0.20**
Fasting blood sugar	0.09	0.11	-0.01	0.08
Tot. Chol	0.05	0.11	-0.01	0.05
Women				
Systolic BP	0.23**	0.17*	0.15*	0.23**
Diastolic BP	0.22**	0.22**	0.131	0.25**
Fasting blood sugar (mmol L^{-1})	0.22**	0.26**	0.19*	0.22**
Tot. Chol	0.04	0.136	0.04	0.04
Men				
Systolic BP	0.00	-0.19	-0.25*	-0.24*
Diastolic BP	0.05	0.19	0.17	0.08
Fasting blood sugar	0.06	0.88**	0.97**	0.67**
Tot. Chol	0.08	0.90**	0.97**	0.68**

**Correlation is significant at 0.01 level, *Correlation is significant at 0.05 level

Table 6: Multivariate-adjusted odds ratios for the presence of cardiovascular disease risk factors according to anthropometric measures

Variables	SBP	DBP	Diabetic	Dyslipidaemia
WC	1.060 (1.012-1.109)	1.048 (1.002-1.095)	1.011 (0.962-1.063)	1.034 (0.976-1.096)
BMI	0.984 (0.887-1.092)	0.990 (0.888-1.105)	1.049 (0.926-1.188)	1.113 (0.985-1.256)
WHR	0.349 (0.013-9.358)	0.033 (0.000-2.331)	1.897 (0.036-100.786)	4.760 (0.331-68.497)
WHtR	1.007 (0.915-1.107)	1.024 (0.928-1.130)	1.018 (0.904-1.147)	0.899 (0.803-1.006)

BMI: Body Mass Index, WC: Waist Circumference, WHR: Waist-to-Hip Ratio, WHtR: Waist-to-Height Ratio, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, Data are presented as odds ratio adjusted for age with 95% confidence interval in parentheses

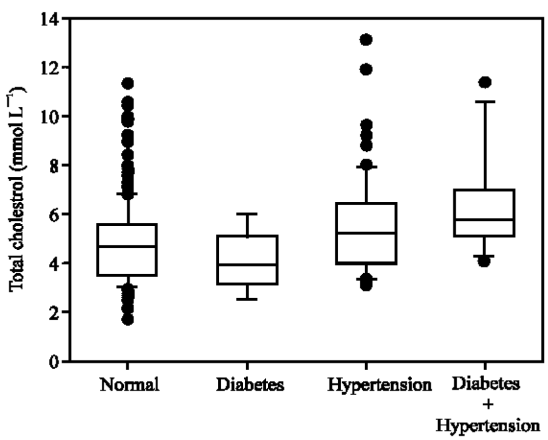

Fig. 4: Cholesterol levels between patients with a different number of comorbidities in cohorts of patients with a primary diagnosis of Type II diabetics, hypertension and diabetes with hypertension. The potential morbidity conditions for diabetic patients included hypertension and dyslipidaemia; those for hypertensives included diabetes mellitus and dyslipidaemia and those for dyslipidaemics included diabetes mellitus and hypertension. The lower and upper margins of the box represent the 25th and 75th percentiles, with the extended arms representing the 10th and 90th percentiles, respectively. The median is shown as the horizontal line within the box. Outlying points are shown individually. All p-values: *<0.05, **<0.001, ***<0.0001 and ns: Not Significant, using polynomial analysis of covariance with adjustment for age and gender

Multivariate-adjusted odds ratios for the presence of cardiovascular risk factors according to anthropometric measures are presented in Table 6. After controlling for potential confounding variables, subjects with abnormal anthropometric measures had higher odds for having cardiovascular risk factors. However, the association between WHR and hypertension (SBP and DBP), BMI and hypertension (SBP and DBP) and WHtR and dyslipidaemia, was not significant.

DISCUSSION

Obesity is a heterogeneous disease associated with life-threatening comorbidities such as diabetes, hypertension and dyslipidaemia (Jousilahti *et al*., 1996). These three diseases account for a huge proportion of the burden of health care cost to society (Colditz, 1999). In most parts of the world, there are increasing trends of obesity (Holdsworth *et al*., 2004). In the present study, the mean BMI of present study population was 25.72±5.97 kg m^{-2} (22.61±3.48 and 27.10±6.33 kg m^{-2} in males and females, respectively). These values are similar to that reported among a Ghanaian population in Accra (Amoah, 2003).

It is also notable that overnutrition is on the increase and is now a major problem even among the Penteco-Charismatic Church members who because of their intermittent fasting were presumed to have a reduced level of obesity, with the prevalence of overweight and obesity (using BMI) being 25.07 and 20.37%, respectively. This study also found the prevalence of obesity in females to be nearly twelve times that in males (Table 3). Social pressures may partly be responsible for the increasing rates of overweight and obesity among Ghanaians. In this study, obesity increased with age up to the age greater or equal to 65 years which is similar to the findings of Amoah who reported that obesity increased with age up to 64 years (Amoah, 2003).

Previous studies among the general population showed that dyslipidemia was not a problem in Ghana (Asibey-Berko and Avorkliyah, 1999). In this study, it was established that the total serum cholesterol levels are higher in the presence of hypertension and diabetes type II. This is contrary to previous work (Eghan and Acheampong, 2003), who found out that total serum cholesterol was higher among hypertensive patient only and LDL-cholesterol was higher in those with hypertension and diabetes. The difference might be due to differences in the study population.

Ghanaians generally associate fatness with beauty in women and success in both sexes. It is, therefore, not surprising that some women and indeed some men are now going out of their way to put on weight in order to appear beautiful or prosperous (Amoah, 2003). Ghanaian men are also perceived to prefer plumb and overweight women to thin ones. This may conceivably contribute to the higher rates of overnutrition among females. It also appears that Ghanaians are now eating more fried and fatty foods, sauces and soups than they did several decades before because of the proliferation of fast food outlets in the urban and peri-urban centres as part of the consequences of urbanisation and Westernisation.

In about 10 years the rate of obesity in Ghanaians has increased several times, from less than 1 to 14% in some populations (Berios *et al*., 1997). It has been observed that an increase in the prevalence of obesity within a population is often noted before a rise in the occurrence of chronic non-communicable diseases such as diabetes, hypertension, stroke, coronary artery disease and some forms of cancer (Poulter *et al*., 1985). With the increasing rate of obesity, the stage is thus set for non-communicable diseases to emerge and threaten the health of Ghanaians. Already there is an increase in the prevalence of some of these diseases. In the late 1950s, the prevalence of diabetes was estimated at 0.2-0.4% in urban areas in Ghana (Dodu, 1958; Dodu and Harthorn, 1966); in a recent study the prevalence of type 2 diabetes in adult Ghanaians from the city of Accra and its environs was estimated at 6.3% (Amoah *et al*., 2002). In this study, the prevalence of type 2 diabetes among the Penteco-Charismatic Ghanaian was found to be 9.54%. Although these prevalence rates were not directly comparable as a result of different sampling methods, they are in accordance with the rising trend of childhood obesity (Holdsworth *et al*., 2004) in present population.

Besides the high degree of obesity, there were clear relationships between BMI and multiple cardiovascular risk factors and comorbidities. Consistent with the 1998 WHO recommended BMI cut-off value of $\geq$25 kg m^{-2} for overweight; from this study, accelerated increased risk beyond this BMI level in the Penteco-Charismatic Ghanaian subjects for most of the morbidities.

This study has also demonstrated that a BMI$\geq$24 kg m^{-2}, a WC$\geq$86 cm, WHR$\geq$0.85, WHtR$\geq$53 are associated with increased health risks. This study therefore independently supports the recent WHO/IASO/IOTF suggestion to consider using lower obesity measurements in Asian and other places to guide health care professionals to promote healthy lifestyles and weight control.

In agreement with other African data (Steyn *et al*., 1998), this study confirmed that Penteco-Charismatic Ghanaians exhibited lower BMI distributions than those seen in Western countries (Kuczmarski *et al*., 1997). The association with parameters of body composition may be strong for some metabolic risk factors but weak for others. While there is a close association between WC and blood pressure (systolic and diastolic), these associations are weaker for total cholesterol and blood sugar (Table 5). Additionally, different aspects of body composition may affect different types of risk factors. For example, central obesity (WC) is less closely related to fasting blood sugar and total cholesterol than general obesity in this study.

The plausibility of the close relationships between risk factors and WC:height (Table 5) that was also found by Hara *et al*. (2002), Hsieh *et al*. (2003), Hsieh and Muto (2005) and Sayeed *et al*. (2003) remains unexplained, since height did not improve the prediction of intra-abdominal fat volume or cross-sectional intra-abdominal fat area in both sexes (Han *et al*., 1997). Considering the close relationship between WC:height and BMI (Table 4). there may be no statistical advantage of BMI over the simple WC:height ratio as a predictor of metabolic risk. The WC:height ratio may thus add to our understanding of the metabolic and body compositional basis of the predictive value of the simple BMI. However, both parameters are not linearly related to each other and therefore cannot be used interchangeably.

The present study also reveals appreciable levels of underweight (6.53%), particularly in men (56%), in the presence of rising obesity. Higher rates of underweight in adult males compared with females (46%) have also been reported in black South Africans (Steyn *et al*., 1998). The

Kumasi area appears to be at the phase of the nutrition transition where undernutrition coexists with overnutrition. Although the cause of the undernutrition in the present study is uncertain, socio-economic factors may possibly play a role. It is to be noted that Ghanaian males tend to be involved in more physically active occupations than do females. Increased energy expenditure in the face of food scarcity may therefore be partly responsible for the relatively higher levels of under nutrition in males.

CONCLUSION

In conclusion, the distribution of BMI and the associations of BMI categories with cardiovascular risk factors and related morbidities in Penteco-Charismatic Ghanaian were similar to those in other Ghanaian populations, but in contrast to other ethnic populations, such as Caucasians. This study also support using BMI, WC, WHR and WHtR levels lower than the WHO recommendation in Caucasians to estimate the prevalence of obesity and for the clinical management of its associated morbidity conditions. Given the health cost implications of diseases such as diabetes mellitus, hypertension, dyslipidemia, coronary heart disease and cancer, which are closely associated with overweight/obesity, these definitions will facilitate the development of a more appropriate preventive strategy to combat these health care problems which are reaching epidemic proportions in Africa.

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