International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 17, No. 2, p. 230-237, 2020

INNSPUB

RESEARCH PAPER OPEN ACCESS

Prevalence of obesity and abdominal obesity in healthy Gabonese adult populations

Hourfil-Gabin Ntougou Assoumou*[1], Armelle Ntsame Affane[1], Noreen Orianna Koumba Madingou[2]

[1]*Ecole Normale Supérieure (ENS), BP : 17009, Libreville, Gabon*

[2]*Institut de Pharmacopée et de Médecine Traditionnelle (IPHAMETRA) BP : Libreville, Gabon*

Key words: Body adiposity, Obesity, Prevalence, Abdominal obesity, Adult population

http://dx.doi.org/10.12692/ijb/17.2.230-237 Article published on August 30, 2020

Abstract

Obesity is complex, multi-factorial chronic disease, which defined as excess adipose tissue, and it is associated with numerous chronic health conditions, such as cardio and cerebrovascular disease.The purpose of this study was to investigate the prevalence of global and abdominal obesity according to obesity indexes in general adult populations living to Libreville. We conducted a population-based, cross-sectional study with a sample of 957 active adult subjects, men and women (mean age 37.47 ± 7.66 years old, 19-66 years old) from Libreville. Anthropometric and biological variables were evaluated by standard methods.The prevalence of abdominal obesity was about 35.05% in women and 8.18% in men as evaluated by WC, and about 37.01% in women and 27.64% in men as evaluated by WHR_1. Anthropometrics variables were increased in men, contrary to body indices that increased in women, excepted WHR_1 that decreased in women. According to BAI, the global obesity was 33.09% *versus* 16.51% for BMI. BAI and WC were appropriate to estimate both global and abdominal obesity. BAI was more important in women (35.22±4.50) compared to men (31.81±3.12) according to increasing WC (>102cm). All global obesity and abdominal obesity indices increased with old age. The prevalence of abdominal obesity was twice as much (35.05%) the prevalence of global obesity in this study. We propose that BAI be used to estimate global obesity in complementarily of BMI. WC remains now the specific index to evaluate abdominal obesity, if absence of technical instruments such as DXA.

* **Corresponding Author:** Hourfil-Gabin Ntougou Assoumou ✉ hourfil@gmail.com

Introduction

For years, obesity, considered as excess body fat, has become a real public health problem worldwide. Its prevalence and mortality are constantly increasing. There are two essential forms of obesity, global obesity and abdominal obesity. These two forms are largely associated with the different risks of chronic metabolic diseases, such as cancer, diabetes, cardiovascular problems (Lindstrom M and *et al.,* 2003; Mokdad AH, 2003), Yusuf and *et al.,* 2005, Hu and *et al.,* 2007). Several indicators of body fat are thus used to characterize the risks of pathologies. Besides these calculated indicators, there are other more complex and more expensive techniques such as DXA and hydrostatic densitometry for broader and more accessible analyzes of adipose tissue (Pateyjohns and *et al.,* 2006). Obesity is usually assessed using the body mass index (BMI) since it is this parameter which is unanimous for the time being in the characterization of individual obesity (Must and al., 1999; Wang and *et al.,* 2002; Chin J, 2014).

But it must be recognized that the BMI has some limits on the qualitative level of fat. Indeed, it does not take into account the distribution of fat or the discrimination of lean mass from fatty mass (Keys and *et al.,* 1972; Bouchard, 2007). It includes bone mass and muscle mass, expressed in individual weight without the possibility of targeting fat, which poses more problems linked to obesity (Garrido-Chamarro and al., 2009; Camhi and *et al.,* 2011; Jackson and *et al.,* 2002) Failing to use the BMI which hardly takes abdominal obesity into account, the waist measurement and the waist-to-hip ratio seem more appropriate to link the risks of excess metabolic dysfunction local fat (Segal *et al* ,. 1987, Hu and *et al.,* 2007), Wei and al ,. 1997; Must and *et al.,* 1999; Yusuf and *et al.,* 2005). Some studies recommend the use of these latter indexes for the analysis of abdominal obesity and as good predictors of cardiovascular risks (Esmaillzadeh and *et al.,* 2004, Pouliot and *et al.,* 1994. However, new, more specific indexes are used to the example of BAI or BFI which have been used for the characterization of obesity instead of BMI (Hu and *et al.,* 2007).

The objective of this study is to assess the prevalence of global obesity and abdominal obesity from the use of different obesity indexes in healthy Gabonese adult's populations living in Libreville.

Material and methods

Study profile and population characteristics

We did a cross-sectional study with a sample of 957 active adult subjects, men and women (mean age 37.47 ± 7.66 years old, from 19 to 66 years) from Libreville. Population was composed by teachers, students and staff members of universities institutions. All active subjects were free of chronic metabolic disorders at time of inclusion. Therefore the subject not belong universities institutions was excluded from this study. The study was approved by the ethical comity. All subjects signed an informed consent for the study. Each participant signed an informed consent to participate in this study.

Anthropometrical measurements

All subjects were evaluated individually in the morning at time beginning classes inside institution (08h 30am). Successively, body weight was evaluated with a manual balance scale, height with a stadio-meter without shoes. The waist circumference was measured on bare skin at the narrowest indentation between the 10^{th} rib and the iliac crest at mid-respiration, according to U.S. Third National Health and Nutrition Examination Survey recommendation. The hip circumference was measured with a tape at the widest point over the greater trochanters. BMI was calculated as the weight in kilograms divided by the square of the height in meters (kg/m^2), and body adiposity index (BAI) was calculated as [(hip circumference) / $(height)^{1.5}$)] -18))[7]. We calculated others parameters as waist-hip-size ratio (WHR_1), waist-height ratio (WHR_2). SBP/DBP ratio was calculated as the SBP divided by the DBP.

As different populations may have different optimal cutoff points for anthropometric measurements in determining obesity, we used cutoff points for WC and WHR that have previously suggested (Wang *et al.*, 2002; Chin J,. 2014; Keys *et al*,. 1972). The WC categories are as follows: (i) normal WC, <80cm for women and <90cm for men; (ii) mild abdominal obesity, 80–88cm for women and 90–102cm for men; and (iii) severe abdominal obesity, ≥88cm for women and ≥102cm for men. The WHR_1 categories are as follows: (i) normal WHR, <0.85 for women and <0.90 for men; and (ii) abdominal obesity, ≥0.85 for women and ≥0.90 for men. We propose the following BAI categories: (i) normal BAI, <25; (ii) middle BAI, 25-30; and (iii) severe BAI >30.

Para-clinical and biological measurements

Blood Pressure (systolic and diastolic) and heart rate were measured one time on the non- predominant arm of the seated position after five minutes of recuperation, using an automated recording device (Automatic Blood Pressure Monitor OMRON M3). Fasting glycaemia was evaluated in the morning by portative system, Accu Chek performa.

Statistical analysis

The data were analyzed using Statistical Analysis System Statview software 5. Results are presented as means ± standard deviation (SD) for quantitative variables and percentage/ proportions in qualitative/nominal values (%). As the cut points of anthropometric measures were different between women and men, analyses were conducted separately for women and men. Significance of differences between means from two compared groups were determined by Student's Unpaired t-test or by one way analysis of variances (ANOVA) with post-hoc Fisher's for detailed multiple comparisons (more than two groups). Bivariate correlations were evaluated with Pearson's coefficient to estimate the correlation between variables from comparative groups.

All hypothesis tests used two-sided tests, and p-values of less than 0.05 ($p<0.05$) were considered statistically significant.

Results

We conducted a population-based, cross-sectional study with a sample of 957 active adult subjects, men and women with a mean age of 37.47 ± 7.66 years old (19-66 years old) from Libreville.

Table 1 show that all variables were significantly different between women and men, excepted for glycaemia. Anthropometrics variables were increased in men, contrary to body indices that increased in women, excepted WHR1 that decreased in women. Clinical parameters significantly increased in women compared to men. Only SDBPR significantly decreased in women. Table 2 presents the prevalence of abdominal obesity and global obesity among all participants. Their prevalence differed according to cut-off values. Global obesity was twice more important according to BAI (33.09%) than global obesity defined by BMI (16.51%).

The prevalence of abdominal obesity was more important according to both indices, WC (35.05%) and WHR_1 (37.05%) in women compared to men. BAI represented the body fat percentage. The data in Table 3 shows the means value of BMI categories according to physical and bio-clinical parameters. All physical and bio-clinical parameters increased, excepted for height and glycaemia that decreased in obese group (BMI>30kg/m²). Age, weight, SBP, DBP and HR were significantly different according global obese group compared to other BMI categories.

Table 1. Anthropometric, clinical and biological parameters according to gender.

Variables	Total (n=957)	Women (n=463)	Men (n=493)	*p-value*
Age (years)	30.47 ± 7.66	29.23 ± 7.36	31.64 ± 7.76	<0.0001
Weight (kg)	70.98 ± 14.33	67.51 ± 14.50	74.22 ± 13.39	<0.0001
Height (m)	1.67 ± 0.08	1.62 ± 0.06	1.71 ± 0.07	<0.0001
BMI (kg/m²)	25.39 ± 4.66	25.73 ± 5.26	25.07 ± 3.99	0.03
WC (cm)	84.69 ± 11.47	83.51 ± 11.75	85.81 ± 11.09	0.002
HS (cm)	98.98 ± 10.05	99.66 ± 10.93	98.34 ± 9.12	0.04
SBP (mm Hg)	126.47 ± 17.15	120.26 ± 14.81	132.28 ± 17.16	<0.0001
DBP (mm Hg)	78.03 ± 11.09	76.39 ± 10.11	79.57 ± 11.74	<0.0001
Glycaemia (g/L)	0.93 ± 0.17	0.93 ± 0.20	0.94 ± 0.14	ns
HR (bpm)	76.92 ± 11.40	79.92 ± 11.05	74.11 ± 11.01	<0.0001

Variables	Total	Women	Men	*p-value*
	(n=957)	(n=463)	(n=493)	
WHR_1	0.86 ± 0.09	0.84 ± 0.08	0.87 ± 0.09	<0.0001
WHR_2	0.51 ± 0.07	0.52 ± 0.07	0.50 ± 0.07	0.0004
BAI	28.01 ± 5.39	30.44 ± 5.48	25.73 ± 4.17	<0.0001
SDBPR	1.63 ± 0.09	1.58 ± 0.13	1.67 ± 0.17	<0.0001

Data are mean ± Standard Deviation.

SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate; H: height; Gly: glycaemia; BMI: body mass index; BAI: body adiposity index; WC: waist circumference; HS: hip size; WHR_1: waist-hip-size ratio; WHR_2: waist height ratio; bpm: bits by minute. Comparisons performed by Unpaired t-Test, p-value<0.05.

Table 2. Prevalence of obesity and abdominal obesity according to different index, BMI, BAI, WC, WHR_1 and WHR_2.

Index thresholds	Normal	Abdominal obesity	Global Obesity
BMI (kg/m²)			
18-25	(n=475) 49.63%		
25-30		(n=304) 31.77%*	
>30			(n=158) 16.51%
BAI			
<25	(n=313) 32.78%		
25-30		(n=326) 34.14%*	
>30			(n=316) 33.09%
WC (cm)			
Women			
<80	(n=215) 46.24%		
80-88		(n=87) 18.71%	
>88		(n=163) 35.05%	
Men			
<90	(n=343) 70.14%		
90-102		(n=106) 21.68%	
>102		(n=40) 8.18%	
WHR_1			
Women			
<0.85	(n=291) 62.99%		
>0.85		(n=171) 37.01%	
Men			
<0.90	(n=356) 72.36%		
>0.90		(n=136) 27.64%	
WHR_2			
<0.46	(n=306) 31.98%		
>0.46<0.62		(n=593) 61.96%	
>.62			(n=58) 6.06%

Data are percentage.

BMI: body mass index; BAI: body adiposity index; WC: waist circumference; HS: waist size; WHR_1: waist-hip-size ratio; WHR_2: waist to height ratio.

*middle BMI and BAI: no specific obesity

Table 3. Anthropometric, clinical and biological parameters according to BMI categories.

	BMI			
Physical parameters	<18^{a} *(n=20)*	>18<25^{b} *(n=475)*	>25-30^{c} *(n=304)*	>30^{d} *(n=158)*
Age (years)	25.95 ± 3.28	28.77 ± 6.59^{bc†}	31.77 ± 7.60^{ac†}	33.63 ± 9.41^{ad†}
Weight (kg)***	46.6 ± 3.66	62.27 ± 7.99	75.59 ± 8.81	91.36 ± 11.91
Height (m)	1.64 ± 0.05^{ab*}	1.67 ± 0.08	1.68 ± 0.08^{ac*}	1.66 ± 0.08^{bcd*}
BMI***	17.45 ± 0.69	22.16 ± 1.91	26.88 ± 1.87	33.23 ± 2.90
WC (cm)***	67.55 ± 3.35	77.41 ± 6.28	88.71 ± 6.71	101.01 ± 9.77
BAI***	22.72 ± 1.51	25.03 ± 3.58	29.26 ± 3.97	35.25 ± 4.59
HS (cm)***	85.15 ± 3.17	92.89 ± 6.20	102.09 ± 6.63	113.02 ± 7.72
WHR_1***	0.44 ± 0.07	0.47 ± 0.05	0.53 ± 0.05	0.59 ± 0.08
WHR_2	0.84 ± 0.12	0.85 ± 0.08^{bc**}	0.87 ± 0.08	0.87 ± 0.11^{bd**}

	BMI			
Physical parameters	<18a *(n=20)*	>18<25b *(n=475)*	>25-30c *(n=304)*	>30d *(n=158)*
Clinical and biological variables				
SBP (mm Hg)	115.90 ± 13.71ac†	122.38 ± 15.28bd†	129.35 ± 17.27cd**	134.44 ± 18.48ad†
DBP (mm Hg)	75.25 ± 10.65ad**	75.09 ± 9.61bc†	79.70 ± 10.88cd**	84.01 ± 12.61bd†
Glycaemia (g/L)	0.92 ± 0.26	0.93 ± 0.15	0.94 ± 0.19	0.96 ± 0.19
HR (bpm)	83.25 ± 12.15ab**	76.08 ± 11.37bd†	76.01 ± 10.95ac**	80.42 ± 11.44cd†
Index SBP/DBP	1.55 ± 0.11ab*	1.64 ± 0.16	1.63 ± 0.16ac*	1.61 ± 0.17

Data are mean ± Standard Deviation.

SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate; H: height; Gly: glycaemia; BMI: body mass index; WC: waist circumference; BAI: body adiposity index; HS: waist size; WHR_1: waist-hip-size ratio; WHR_2: waist height ratio; bpm: bits by minute. Comparisons performed by Unpaired t-Test: p-Value: *p<0.05; **p<0.01; †p<0.0001; a : <18; b: 18-25; c: 25-30; d: >30. ***significantly although groups.

Table 4. Physical, clinical and biological parameters according to waist circumference categories in women and men.

	WC categories for Women			WC categories for Men		
Variables	<80 a (n=215)	>80<88 b (n=87)	>88 c (n=163)	<90 a (n=343)	>90<102 b (n=106)	>102 c (n=40)
Age (years)m***	27.32 ± 6.14ac***	28.67 ± 5.27bc***	32.15 ± 8.82	29.38 ± 6.20	34.85 ± 7.55	42.03 ± 8.71
Weight (kg)w/m***	56.10 ± 6.86	68.12 ± 5.05	82.06 ± 11.54	68.43 ± 8.62	83.37 ± 8.10	100.72 ± 14.02
Height (m)	1.61 ± 0.06ac*	1.62 ± 0.06	1.63 ± 0.06	1.72 ± 0.07ac*	1.72 ± 0.07	1.74 ± 0.07
BMI (kg/m^2)w/m***	21.54 ± 2.47	25.98 ± 2.18	31.00 ± 4.10	23.22 ± 2.49	28.20 ± 2.08	33.15 ± 3.55
WC (cm) w/m***	73.32 ± 4.60	83.92 ± 2.09	96.65 ± 7.09	80.08 ± 5.82	95.27 ± 3.36	110.30 ± 8.91
HS (cm)w/m***	91.20 ± 6.44	100.22 ± 5.13	110.29 ± 7.99	94.39 ± 6.54	105.48 ± 5.86	114.18 ± 6.75
SBP (mm Hg) m***	116.56 ± 12.92ac***	120.43 ± 14.22ab*	125.31 ± 16.62bc*	128.76 ± 15.37	136.50 ± 15.26	150.75 ± 20.80
DBP (mm Hg)	74.04 ± 9.38ac***	76.54 ± 9.14ab*	79.43 ± 10.84bc*	76.97 ± 10.41ac***	84.04 ± 11.56ab***	89.95 ± 13.60bc**
Glycaemia (g/L)	0.91 ± 0.18	0.94 ± 0.13	0.95 ± 0.25	0.93 ± 0.14	0.96 ± 0.02	1.00 ± 0.14
HR (bpm)	79.19 ± 10.53	79.95 ± 11.13	80.80 ± 11.82	72.84 ± 10.89	76.45 ± 10.29	78.45 ± 11.66
WHR_1	0.83 ± 0.09ac***	0.84 ± 0.06	0.86 ± 008bc*	0.86 ± 0.08ac***	0.89 ± 0.08ab***	0.93 ± 0.11bc*
WHR_2w***	0.47 ± 0.05	0.52 ± 0.03	0.58 ± 0.07	0.47 ± 0.05	0.55 ± 0.04	0.61 ± 0.08
SDBPR	1.58 ± 0.13	1.58 ± 0.12	1.59 ± 0.15	1.68 ± 0.16ab*	1.64 ± 0.18	1.69 ± 0.21
BAI***	26.59 ± 3.66	30.63 ± 3.48	35.22 ± 4.50	24.07 ± 3.24	28.98 ± 3.14	31.81 ± 3.12

Data are mean ± Standard Deviation.

SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate; Gly: glycaemia; BMI: body mass index; HS: hip size; WC: waist circumference; WHR_1: waist hip ratio; WHR_2: waist height ratio; SDBPR: systolic diastolic blood pressure ratio; BAI: body adiposity index. Relative comparisons performed by Unpaired t-Test. p-Value: *p<0.05; **p<0.01; ***p<0.0001; a: lower WC, b: moderate WC, c: higher WC according to men and women, respectively; w***p<0.0001(for women); m***p<0.0001 (for men) w/m***both women and men p<0.0001. Variables***: significantly in all groups (<0.0001).

The data in Table 4 shows the relationship between physical, bio-clinical variables according to both WC threshold and gender. For both genders, all variables significantly increased with elevated WC. BAI increased significantly with high WC. BAI was more important in women (35.22±4.50) compared to men (31.81±3.12) according to high WC (>102cm) Fig.1.

All global obesity and abdominal obesity indices increase with old age. Fig. 2 shows different correlations between BAI, dependent variable and other indices of obesity. BAI significantly associated with three indices of obesity, nevertheless so more with waist circumference according to coefficient value *(r=1.30, p<0.0001).*

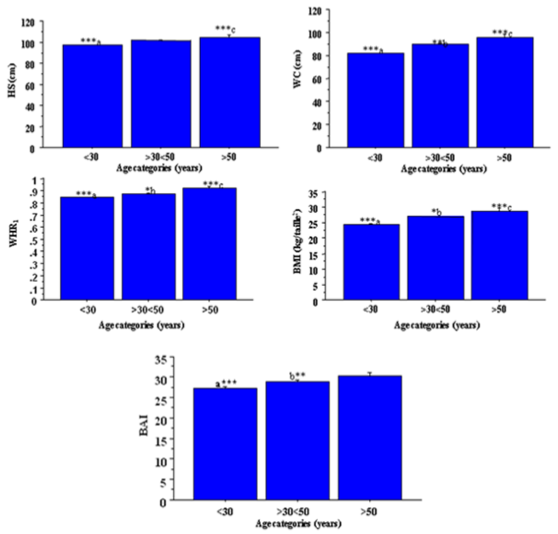

Figure 1. Representation of index, WHR_1, WC, BAI, HS and BMI according to Age categories

WHR_1: waist-hip-size ratio; WC: waist circumference; BAI: body adiposity index; HS: hip size; BMI: body mass index, **p<0.05, **p<0.001, ***p<0.0001;* ***a: <30 vs >30<50; b: 30<50 vs >50, c: <30vs>50***

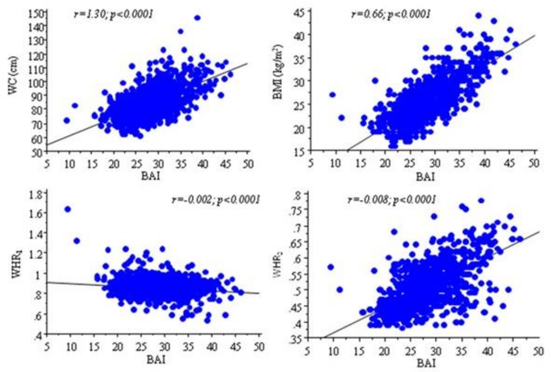

Figure 2. Person's correlations between body adiposity index and waist circumference, waist-to-hip ratio, waist-to-height ratio and body mass index, respectively.

Discussion

In this study, we evaluated the prevalence of both obesity and abdominal obesity according to some indices largely recognized in many studies, as body mass index (BMI), waist circumference (WC), body adiposity index (BAI), waist hip size (WHR_1) and waist to height ratio (WHR_2). The principal results of this study are the following: (i) the prevalence of global obesity was 33.09%, 16.51% and 6.06% for BAI, BMI and WHR_2, respectively. These indices were specific to establish the prevalence of global obesity; (ii) the prevalence of abdominal obesity were 35.05% and 8.18% according to WC thresholds in women and men, respectively. With WHR_1 we are 37.01% in women and 27.64% in men. BAI seemed to be the best to identify obese subjects compare to body mass index. According to previous observations, BMI underestimated the composition of the body adiposity. BMI was relatively inaccurate in subjects with high lean body mass, such as athletes, and it cannot be generalized among different ethnic groups (Segal *et al.*, 1987; Garrido-Charmorro *et al.*, 2009). Such limitations might be more relevant when dealing with the metabolic states associated with altered body fat distribution. Somebody with a normal BMI can to be an excess fat mass, conversely.

Our study demonstrates that the prevalence of global obesity depends to two indices which gave different results. Previous studies reported that BMI was routinely applied to estimate body fat and to classify overweight and obesity, but had clear well known limitations (Jackson *et al.*, 2002). Furthermore, the BMI does not consider the differences between men and women. Those reasons lead us to suggest the utilization of a new index, the BAI, which was calculated with the hip circumference and the height (weight is not needed). The BAI measurement requires very simple instrumentation, being very useful in developing countries or remote places where accurate measurement of weight can be difficult, or scales are not available (Hu *et al.*, 1987). This is an important advantage of BAI over BMI. Keys *et al* reported a high correlation between BMI and adiposity (Keys *et al.*, 1972). In this study we have not evaluated fat composition.

In a previous study, body fat, measured by DXA, was used as the criterion for body fat (BF), and the reported correlation of BAI with body fat percentage was greater than with BMI. Our previous study had reported that BFI, a new index of global adiposity study was correlated with BMI (Ntougou Assoumou *et al.*, 2011). BFI was also correlated with WC and BAI (data not shown). BAI was found to be a strong predictor of BF% in Mexican-American subjects of widely varying adiposities, and this result was confirmed in a study of African-Americans (Hu *et al.*, 2007**)**. BAI had better concordance and a significantly stronger correlation with BF than BMI, although BAI was inaccurate at low levels of adiposity in European-American adults (Johnson *et al.*, 2012). Interestingly, BAI has an advantage over BMI for defining adiposity, but BAI overestimated BF in men and underestimated it in women (Johnson *et al.*, 2012).

From our results, we recommend the use of that BAI to establish the prevalence of global obesity but not for abdominal obesity. With BAI, we found about 36% of obese subjects, while we found 16% with BMI. However, WC is yet the best predictor of the abdominal obesity. Generally, the evidence is that global obesity and abdominal obesity are characterized by metabolic disorders, such as inflammation. The abdominal obesity or android obesity is more dangerous. Abdominal obesity is associated with alterations in immunity, a chronic low-grade inflammation in which there are elevated circulating pro-inflammatory cytokines.

However, it is unclear how obesity precisely triggers inflammation. Several hypotheses have been proposed [25°]. One hypothesis suggests that the overloading of adipocytes with fat overwhelmingly increases the infiltration of macrophages.

These processes may cause the subsequent differentiation and activation of cytotoxic T cells, which initiate and propagate inflammatory cascades (Garrido-Chamorro *et al.*, 2009). Second hypothesis suggests that as adipose tissues enlarge, tissues become relatively hypoxic. Hypoxia within adipose tissue may activate inflammatory pathways (Ntougou Assoumou *et al.*, 2011). The last hypothesis is that overloaded adipocytes can themselves directly activate immune pathogen-sensors that cause chronic inflammation (Shi *et al.*, 2006). Our study reveals that about third of this population have abdominal obesity, and presents probably a risk to develop a chronic inflammation.

Conclusions

In this study, the prevalence of abdominal obesity was too times higher than the prevalence of global obesity. BMI underestimated the prevalence of global obesity and inadequate or inexact the body adiposity. However, BAI overestimates the body adiposity and seemed to be appropriate to estimates global obesity. We propose that BAI to be used to estimate global obesity in complementarity of BMI. WC still remains the specific index to evaluate abdominal obesity, if technical instruments are not available. The limitations of this study were based on the low participant's number and the biological variables were insufficient. These data could be completed by further investigations.

Acknowledgments

We thank Pr Louis Clément OBAME in helping us proofreading this article. None of the authors have indicated any financial conflict of interest.

References

Bergman RN, Stefanovski D, Buchanan TA, Sumner AE, Reynolds JC. 2011. A better index of body adiposity. Obesity (Silver Spring) **19,** 1083-89.

Bouchard C. 2007. BMI, fat mass, abdominal adiposity and visceral fat: where is the 'beef'? Int J Obes (Lond) **31,** 1552-53.

Camhi SM, Bray GA, Bouchard C, Greenway FL, Johnson WD. 2011. The relationship of waist circumference and BMI to visceral, subcutaneous, and total body fat: sex and race differences. Obesity (Silver Spring) **19,** 402-08.

Chin Epidemiol J. 2014. Abdominal obesity and its association with health-related quality of life in adults: a population-based study in five Chinese cities. Health and Quality of Life Outcomes **12,** 100.

Esmaillzadeh A, Mirmiran P, Azizi F. 2004. Waist-to-hip ratio is a better screening measure for cardiovascular risk factors than other anthropometric indicators in Tehranian adult men. Int J Obes Relat Metab Disord **28(10),** 1325-32.

Garrido-Chamorro RP, Sirvent-Belando JE, Gonzalez-Lorenzo M, Martin-Carratalam L, Roche E. 2009. Correlation between body mass index and body composition in elite athletes. J Sports Med Phys Fitness **49,** 278-84.

Hu D, Xie J, Fu P, Zhou J, Yu D, Whelton PK, He J, Gu D. 2007. Central rather than overall obesity is related to diabetes in the Chinese population: the InterASIA study. Obesity (Silver Spring) **15(11),** 2809-16.

Jackson AS, Stanforth PR, Gagnon J, Rankinen T, Leon AS. 2002. The effect of sex, age and race on estimating percentage body fat from body mass index: The Heritage family study. Int J Obes Relat Metab Disord **26,** 789-96.

Johnson W, Chumlea WC, Czerwinski SA, Demerath EW. 2012. Concordance of the recently published body adiposity index with measured body fat percent in European-American adults. Obesity (Silver Spring) **20,** 900-03.

Keys A, Fidanza F, Karvonen MJ, Kimura N, Taylor HL. 1972. Indices of relative weight and obesity. J Chronic Dis **25,** 329-43.

Lindstrom M, Isacsson SO, Merlo J. 2003. Increasing prevalence of overweight, obesity and physical inactivity: two population-based studies 1986 and 1994. Eur J Public Health. **13(4),** 306-312.

Mokdad AH, Ford ES, Bowman BA, Dietz WH, Vinicor F, Bales V. S2001. Prevalence of obesity, diabetes, and obesity-related health risk factors, JAMA **289(1),**76-79. https://doi.org/10.1001/jama.289.1.76 PMID: 12503980.

Must A, Spadano J, Coakley EH, Field AE, Colditz G. 1999. The disease burden associated with overweight and obesity. JAMA **282,** 1523-1529.

Ntougou Assoumou HG, Pichot V, Barthelemy JC, Dauphinot V, Celle S, Collet P, Gaspoz JMl, Roche F. 2011. Obesity-related autonomic nervous system disorders are best associated with body fat mass index, a new indicator. Int J Cardiol **153(1),** 111-13.

Pateyjohns IR, Brinkworth GD, Buckley JD, Noakes M, Clifton PM. 2006. Comparison of three bioelectrical impedance methods with DXA in overweight and obese men. Obesity (Silver Spring) **14,** 2064-70.

Pouliot MC, Despres JP, Lemieux S, Moorjani S, Bouchard C, Tremblay A, Nadeau A, Lupien PJ. 1994. Waist circumference and abdominal sagittal diameter: best simple anthropometric indexes of abdominal visceral adipose tissue accumulation and related cardiovascular risk in men and women. Am J Cardiol **73(7),** 460-68.

Rahman M, Berenson AB. 2010. Accuracy of current body mass index obesity classification for white, black, and Hispanic reproductive-age women. Obstet Gynecol **115,** 982-88.

Segal KR, Dunaif A, Gutin B, Albu J, Nyman A. 1987. Body composition, not body weight, is related to cardiovascular disease risk factors and sex hormone levels in men. J Clin Invest **80,** 1050-55.

Shi H, Kokoeva MV, Inouye K, Tzameli I, Yin H, Flier JS. 2006. TLR4 links innate immunity and fatty acid-induced insulin resistance. J Clin Invest **116,** 3015-25.

Wang W, Wang K, Li T, Xiang H, Ma L, Fu Z, Chen J, Liu Z, Bai J, Feng J, Jin S, Li Y, Qin R, Chen H. 2002. A discussion on utility and purposed value of obesity and abdomen obesity when body mass index, waist circumference, waist to hip ratio used as indexes predicting hypertension and hyper-blood glucose. Zhonghua Liu Xing Bing Xue Za Zhi. Feb **23(1),**16-9.

Wei M, Gaskill SP, Haffner SM, Stern MP. 1997. Waist circumference as the best predictor of noninsulin dependent diabetes mellitus (NIDDM) compared to body mass index, waist/hip ratio and other anthropometric measurements in Mexican Americans–a 7-year prospective study. Obes Res **5(1),** 16-23.

Wing RR, Matthews KA, Kuller LH, Meilahn EN, Plantinga P. 1991. Waist to hip ratio in middle-aged women. Associations with behavioral and psychosocial factors and with changes in cardiovascular risk factors. Arterioscler Thromb **11(5),** 1250-57.

Yusuf S, Hawken S, Ounpuu S, Bautista L, Franzosi MG, Commerford P, Lang CC, Rumboldt Z, Onen CL, Lisheng L, Tanomsup S, Wangai P, Razak F, Sharma AM, Anand SS. 2005, INTERHEART Study Investigators. Obesity and the risk of myocardial infarction in 27,000 participants from 52 countries: a case–control study. Lancet **366(9497),** 1640-49.