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Research Article

Determination of Waist Circumference Thresholds for the Diagnosis of Abdominal Obesity in Adults of African Origin in the Maritime Region of Togo

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Abstract

Abdominal obesity is associated with a major risk of cardiometabolic diseases. The waist circumference thresholds currently used in Togo are based on European data and have not been validated for local African populations. This discrepancy can lead to diagnostic errors and suboptimal management. The objective of this study was to determine the optimal waist circumference thresholds for identifying the cardiometabolic factors characteristic of abdominal obesity. A prospective cross-sectional study was conducted on 506 adults aged 15-59 years in the maritime region of Togo, including 119 subjects without metabolic disease for the establishment of reference intervals. The limits of 2.5 to 97.5 percentiles were used to determine the reference intervals. Biochemical analyses were performed in accordance with ISO 15189 requirements. The diagnostic thresholds associated with the presence of cardiometabolic risk factors were determined by analyzing the ROC curves using the Youden method. In women, waist circumference thresholds of 82, 86, 86 and 91 cm were significantly associated with: Total Cholesterol ≥2.0 g/l, Triglycerides ≥1.50 g/l, Blood Glucose ≥1.00 g/l and BP ≥130/85 mmHg, respectively. The optimal threshold was set at 91 cm. In men, waist circumference thresholds of 71, 73, 74, 82 and 93 cm were significantly associated with: triglycerides ≥1.50 g/l, Blood glucose ≥1.00 g/l, Blood glucose ≥1.26 g/l, Total cholesterol ≥2.0 g/l and blood pressure ≥130/85 mmHg. The optimal threshold selected was 82 cm. This study establishes waist circumference thresholds specific to our black population in the maritime region of Togo: 91 cm for women and 82 cm for men. These values, which are lower than international standards, are significantly associated with the main cardiometabolic risk factors and enable better prevention of metabolic syndrome adapted to local characteristics.

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Keywords

Abdominal Obesity, Waist Circumference, Reference Ranges, African Population, Togo

1. Introduction

The World Health Organization (WHO) defines obesity as "abnormal or excessive fat accumulation that impairs health." It can increase the risk of type 2 diabetes and heart disease, affect bone health and reproduction, sleep, physical activity, and increase the risk of certain cancers. According to the WHO, in 2022, the global prevalence of overweight and obese adults aged 18 years and older was 43% and 16% respectively, compared to 39% and 13% in 2014 [1-3]. World Obesity's Atlas of Obesity Data for the WHO African Region 2021 indicates that prevalence in the 35 countries ranged from 3.3% to 36.2% for obesity and from 10.1% to 36.0% for overweight [4]. Abdominal obesity, a specific form of general obesity where excess fat is concentrated in the abdomen, is particularly dangerous because it increases the risk of developing serious diseases such as type 2 diabetes, cardiovascular disease, and metabolic syndrome, regardless of body mass index (BMI). Its prevalence varies considerably according to gender, age, and diagnostic criteria [5]. Waist circumference (WC) measurement is the anthropometric indicator of choice for the diagnosis of abdominal obesity because of its simplicity, reproducibility, and strong correlation with the amount of visceral adipose tissue [6]. Different thresholds for diagnosing abdominal obesity have been established for Caucasian populations (≥94 cm in men and ≥80 cm in women) and Asian populations (≥90 cm in men and ≥80 cm in women). The US National Cholesterol Education Programme (NCEP) uses a WC ≥ 102 cm for men (M) and ≥88 cm for women (W). In the absence of study data on black African populations, the International Diabetes Federation (IDF) and the WHO have recommended the use of WC criteria of ≥94 cm for men and ≥80 cm for women [7].

In Togo, in 2018, the overall prevalence of abdominal obesity in urban was 29.4% in men compared to 85.2% in women [3]. The 2021 STEPS survey revealed that abdominal obesity according to IDF criteria is becoming increasingly prevalent, especially among women, as the average waist circumference increased from 77.7 cm in men and 78.5 cm in women in 2010 respectively to 80.7 cm in men and 86.3 cm in women [8]. The absence of thresholds established from data on an African population, the increase in the prevalence of abdominal obesity in Togo, and the existence of differences in body composition, adipose tissue distribution, and metabolic profiles between populations of African and Caucasian origin are all factors that require verification of the adequacy of the diagnostic thresholds used.

As demonstrated in Tunisia, determining specific thresholds for identifying abdominal obesity is a valuable tool in clinical practice and public health [9]. Are the thresholds in sub-Saharan Africa different from those in Caucasian, Mediterranean or African-American populations?

The objective of this study was to determine the optimal waist circumference thresholds for identifying the cardiometabolic factors characteristic of abdominal obesity.

2. Material and Methods

2.1. Study Setting

A reasoned approach was used to identify the study region. The maritime region was the most densely populated region, with 43.6% of the Togolese population, compared to less than 21% for the other regions. It was chosen in order to have a presence of the majority of all ethnic groups represented in Togo. This region includes the Autonomous District of Greater Lomé (DAGL) in the Gulf Prefecture, which had the highest population density (6,595 inhabitants per square meter). Among the six other prefectures in this region (Zio, Yoto, Bas-Mono, Lacs, Vo and Avé), a random draw was used to select 25%, or two prefectures, namely Vo and Zio. A reasoned selection was made to select 25% of the 4 municipalities in each selected prefecture, giving priority to the prefectural capitals where markets and health centers are located. Thus, for the prefecture of Zio, the municipality of Tsévié was selected. Similarly, the municipality of Vogan was selected from among the 4 municipalities of Vo [10].

In the DAGL, 25% of the 13 municipalities were chosen at random. The three municipalities selected were: Aflao-Gakli, Agoè-Nyivé and Sanguéra [11, 12]. A reasoned approach based on the criteria of the availability of a market and/or place of worship with a health center was used to identify the recruitment and sampling sites. In the municipalities of Vogan and Tsévié, health centers located not far from the markets were used. Biochemical analyses were carried out at the Wossinu and Gbogbo Polyclinic laboratories.

2.2. Type and Duration of Study

This was a prospective cross-sectional study, which took place over a period of five months from October 2023 to March 2024.

2.3. Study Population

The study population consisted of adults of both sexes, aged 15 to 59, residing in the Autonomous District of Greater Lomé and the Maritime region, without distinction of religion, ethnicity or socioeconomic status, according to the inclusion and exclusion criteria.

2.3.1. Inclusion and Exclusion Criteria

All adults capable of answering the study questions were included in this study. All participants gave their free and informed consent to be included in the study, including the blood samples required for biochemical testing.

Excluded were pregnant women, individuals aged 60 years and older [13], and subjects with a mental state that did not allow them to respond coherently to the various questions or a physical condition that did not allow anthropometric measurements to be taken.

2.3.2. Study Population Size

The size of the study population was determined to ensure that it was representative of the age and gender of the populations of the DAGL and the maritime region of Togo. According to the 5^{e} General Population and Housing Census (RGPH-5) of 2022, the population of Togo was 8,095,498, with the following percentage distribution by age group: [15-40] years (39.17%), [40-50 years (8.4%) and [50-60] years (4.75%). The population of the DAGL represented 27.03% and the rest, while the Maritime Region represented 16.63% of Togo's inhabitants. The other regions of Plateaux, Savanes, Kara, and Centre had inhabitants representing 20.21%, 14.13%, 12.17%, and 9.82% of the Togolese population, respectively [10]. The principle of minimum study population size for determining biological reference intervals based on a 95% confidence interval from the 2.5th to the 97.5th percentile was used, i.e., 120 male and female subjects for the Central Region, which is the least populated region. Proportionally based on the 9.82% from the central region, the expected population sizes for the rest of the maritime region and the DAGL were 203 and 330 subjects, respectively. This means that a total of 533 subjects will be recruited, taking into account the weight of the age groups.

2.4. Measurement of Anthropometric, Cardiovascular and Biochemical Parameters

The survey was conducted by a team consisting of nurses, a senior laboratory technician, a biochemist-nutritionist and a biologist specializing in physio-pharmacology, all trained in good laboratory practices in accordance with ISO 15189 version 2012. The questionnaire was pre-tested with anthropometric measurement sessions to ensure the reproducibility of the measurements.

Recruitment was voluntary, following a two-week community awareness campaign prior to the start of the survey. Interested individuals voluntarily came to our survey centers after their eligibility was verified according to our inclusion and exclusion criteria.

The questionnaire was completed by the investigator through a face-to-face interview at the various collection sites. Sociodemographic data including age, gender, educational level, region of origin and ethnic group were recorded.

For anthropometric variables, measurements were taken of weight (kg), height (cm), waist circumference (cm), hip circumference (cm), and abdominal skinfold thickness (ASFT) [14].

Weight was measured with feet slightly apart using a bathroom scale with an accuracy of 0.5 kg. Height was measured using a $^{SECA®}$(Germany) height gauge to the nearest 1 cm, while breathing normally. Waist circumference was measured using a *WIN TAPE Measuring tape* (China Wintape Co., Ltd) retractable tape measure with an accuracy of 1 cm, placed horizontally halfway between the costal margin and the anterior superior iliac spines. The PCA was measured using a Harpenden caliper or thickness gauge (Harpenden, England). Measurements were taken with an accuracy of 0.2 mm at the umbilical point, located 5 cm to the right of the umbilical scar. This distance was measured using a tape measure. The subject stood upright with arms relaxed at their sides, and the PCA was measured vertically at the umbilical point. Both sides of the fold were approximately parallel and the Harpenden caliper was placed at 90 degrees to the fold mark. The measurement was taken 2 seconds after releasing the Harpenden caliper and was repeated 3 times to use the average of these measurements. The Quételet index or body mass index (BMI) was calculated as the ratio of weight to the square of height (kg/m^2). WHO criteria were used to identify obese or overweight subjects with BMI ≥ 30 kg/m^2 and ≥ 25 kg/m^2 as being overweight [15].

Systolic and diastolic blood pressure was measured in millimeters of mercury (mmHg) using Spingler® (France) blood pressure monitors after 15 minutes of rest. It was taken three (03) times immediately after rest in participants. Blood pressure in participants was calculated as the average of the three readings.

For biochemical measurements, 5 ml venous blood samples were collected in additive-free tubes from subjects who had fasted for 12 hours. Standard blood collection and assay procedures compliant with ISO 15189 requirements were used. Biochemical analyses were performed on a *Mindray BS-430* automated spectrophotometric analyzer **(**Mindray, India). It was used for the following tests:

1) Blood glucose (GLY), using glucose oxidase in Trinder mode (H_2O_2 - Peroxidase)
2) Total cholesterol (TC), using cholesterol esterase hydrolysis (H_2O_2 formed in the subsequent enzymatic oxidation of cholesterol by cholesterol oxidase)
3) Triglyceride levels (TG) with the action of lipoprotein

lipase.

4) High-density lipoprotein cholesterol (HDL C) fraction, using the direct method: polyethylene glycol (PEG)-modified enzyme/sulphate α-cyclodextrin method.

All biochemical analyses were performed using a Mindray reagent kit. Multi-parameter sera of "normal and pathological" levels (Multi control Sera N "Mindray" Ref: (MQ-ClinChem M-162) were used to ensure the reproducibility of measurements and the identification of any biases [16].

2.5. Criteria for Identifying Cardio-metabolic Factors Characteristic of Abdominal Obesity

The metabolic profiles of all subjects in the study, including those without any metabolic pathology, were determined using the following pathological criteria: blood glucose ≥ 1.00 g/L (5.5 mmol/L), triglycerides ≥ 1.50 g/L (1.7 mmol/L), HDL cholesterol < 0.40 g/L (men) and < 0.50 g/L (women), and blood pressure ≥ 130/85 mmHg [17, 18].

The specific criteria used to determine the optimal thresholds or limit values for waist circumference in the presence of cardiometabolic risk factors were: blood glucose ≥ 1.00 g/L and ≥ 1.10 g/L, blood glucose ≥ 1.26 g/L, triglycerides ≥ 1.50 g/L and high blood pressure ≥ 130/85 mmHg [17, 18].

2.6. Ethical Considerations

This study was authorized by the Bioethics Committee for Health Research of the Ministry of Health and Public Hygiene under number 021/2022/CBRS on 23 June 2022. Informed consent was obtained from each participant. The anonymity of the subjects included in this study was maintained. The results obtained in this study were used exclusively for scientific purposes.

2.7. Data Analysis

The various data were recorded in a Microsoft Excel 2020 file. The results were represented as the mean (M) ±SD when the distribution was normal. They were analyzed using R software version 3.5 (Foundation for Statistical Computing-Vienna, 2018). Analysis of variance (ANOVA) was used to compare the means of the anthropometric data. The waist circumference thresholds above which abdominal fat accumulation would be characterized by the presence of cardiometabolic factors were determined using the maximum sum of sensitivity and specificity ≥ 50 1 of the Youden method. This method uses the area under the curve (ROC), which is a statistical measure used to evaluate the performance of a classification model in diagnostic or predictive contexts. Regarding reference limit values, in subjects free of any metabolic pathology, the Shapiro-Wilk test was used to determine normality and Grubbs' test to detect outliers. Limits of 2.5 to 97.5 percentiles were used to determine reference intervals when the normality assumption was rejected and mean +/-1.96SD when this assumption was accepted. The significance threshold used was 5%.

3. Results

3.1. Demographic Aspects and Various Characteristics

A total of 581 participants took part in the survey. Of these participants, 75 subjects (12.9%) were excluded. The exclusions included 37 subjects (6.4%) aged 60 years and older and 7 subjects (1.2%) aged under 15 years. In addition, 13 participants (2.2%) declined to participate because they refused to undergo the required blood test, while 10 participants (1.7%) lost interest in the study during recruitment. Finally, 8 participants (1.4%) were excluded for failing to comply with the 12-hour fasting protocol prior to the biological tests. Thus, the final sample comprised 506 participants (87.1%) who were included in the statistical analyses. This sample of 506 adults consisted of 238 men and 268 women, with a male/female sex ratio of 0.89. For both sexes, the minimum age observed was 16 years. The geographical distribution of our sample was as follows: 366 participants came from the Autonomous District of Greater Lomé, while 73 individuals were recruited in Tsévié and 67 in Vogan. Among the three targeted recruitment municipalities in the DAGL, the village of Adidogomé, bordering the municipality of Sanguéra, was used most frequently for recruitment. Figure 1 shows a map of Togo with the recruitment locations and regions of origin of the ethnic groups, along with their numbers [12].

Figure 1 shows that the majority ethnic group covered by the study is the Ewé (293) [11].

The average age of men was 28.16 ±12.9 years, compared to 32.37 ±13.5 years for women ($p < 0.0004$). Subjects were recruited to ensure representativeness of the age groups [15-40], [40-50] and [50-60] years Figure 2 shows the percentages of the different age groups in the study.

The proportions of the three age groups were significantly different (p=0.0004). The [15-40] age group was the most represented (70.75%). Men were under-represented in the median age group.

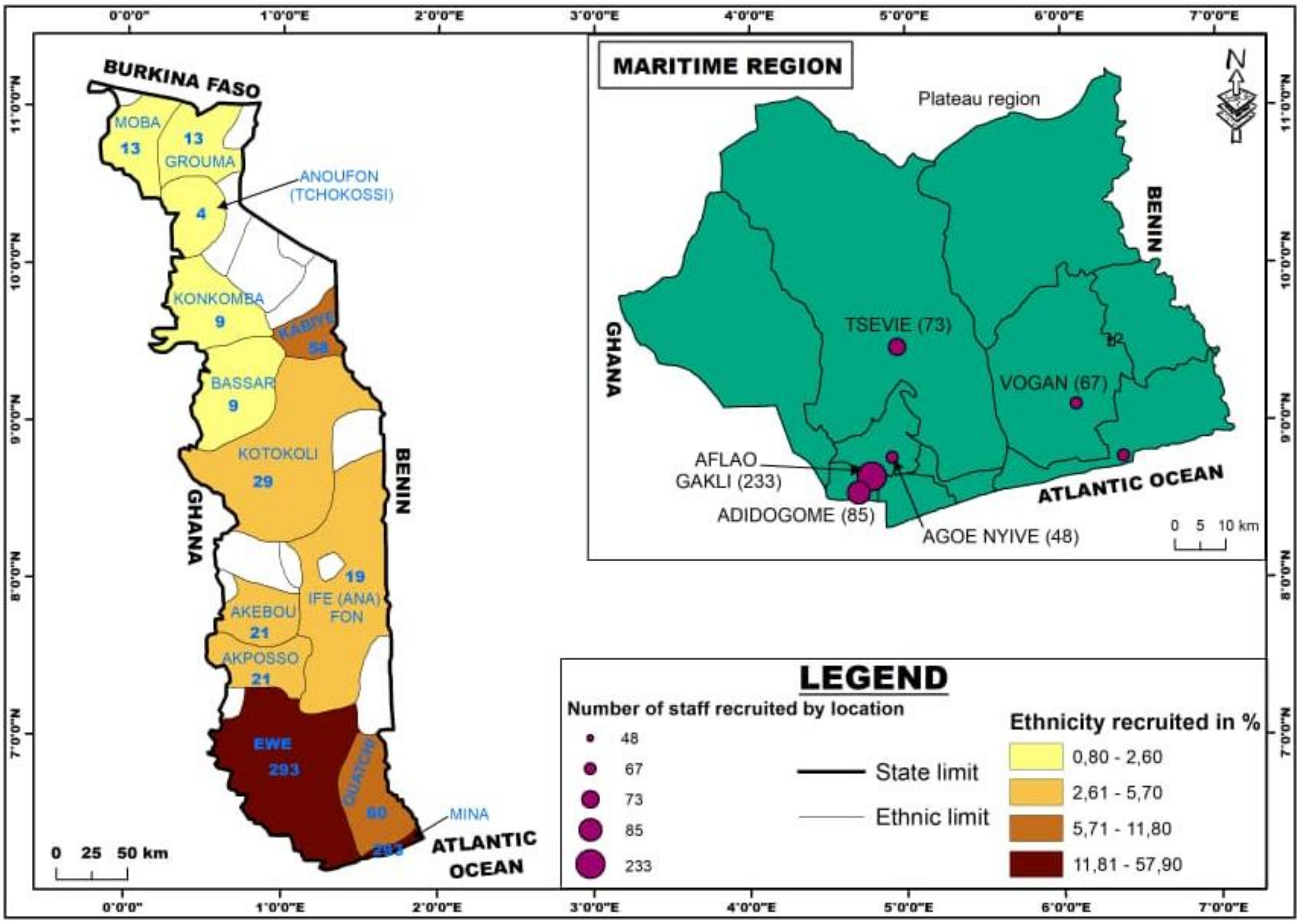

Figure 1. *Map of Togo showing the recruitment locations and regions of origin of the ethnic groups.*

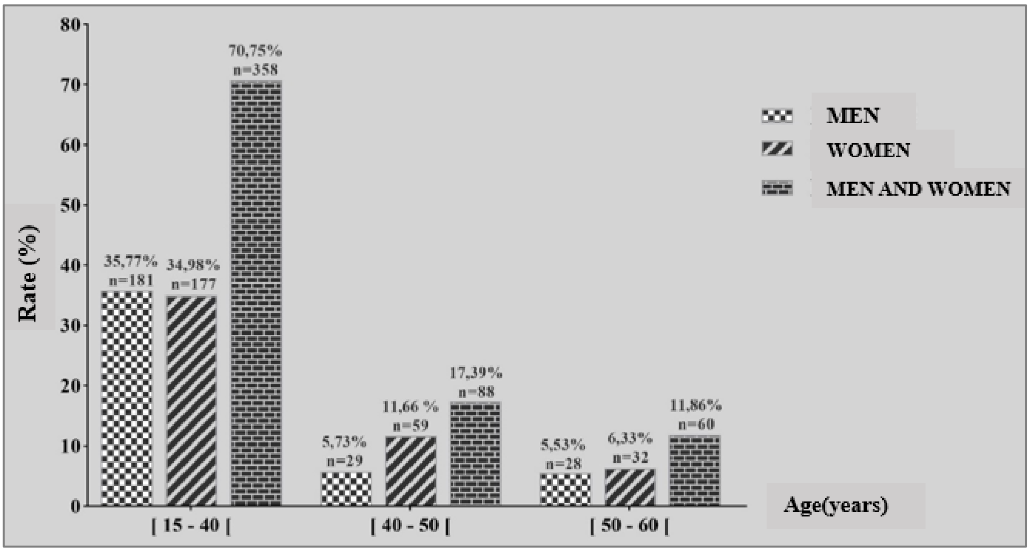

Figure 2. *Distribution of the study population by age group and gender.*

3.2. Anthropometric and Biochemical Characteristics of the Study Population

Analysis of the participants' anthropometric and biochemical measurements enabled their metabolic profile to be characterized. These data reveal a significant difference in PCA, with significantly higher values in women (22.07 ± 7.9 mm) compared to men (16.22 ± 6.9 mm). All of these results are summarized in Table 1.

Table 1. *Anthropometric and biochemical characteristics of the population studied in the Maritime region.*

Variable	MEN (n=238) Min	Max	2.5th Percentiles	97.5th Percentiles	M ± SD	WOMEN (n=268) Min	Max	2.5th Percentiles	97.5th Percentiles	M ± SD	*p value
BMI (kg/m^2)	15.4	39.1	17.6	33.4	22.7 ±3.8	10.7	48.2	18.5	44.1	26.4 ±6.4	<0,0001
WC (cm)	56	113	62	107	76 ±11	53	121	61	115	82 ±14	<0,0001
AFS* (mm)	5.8	36.8	7.2	33.7	16.2 ±6.9	8.8	48.0	9.3	40.5	22.1 ±7.9	<0,0001
Blood glucose (g/l)	0.58	4.04	0.70	1.78	0.88 ±0.38	0.52	4.68	0.64	1.65	0.88 ±0.31	>0,9999
Total cholesterol (g/l)	0.80	3.49	1.06	2.50	1.70 ±0.38	0.62	3.17	1.13	2.81	1.84 ±0.42	0,0002
HDL cholesterol (g/l)	0.11	1.40	0.25	0.77	0.50 ±0.14	0.18	0.96	0.29	0.84	0.54 ±0.13	>0,999
Triglycerides (g/l)	0.30	3.57	0.35	2.19	0.85 ±0.48	0.22	3.56	0.34	2.27	0.87 ±0.51	>0,999

WC: Waist circumference (mean) ± SD (standard deviation): AFS: Abdominal skinfold thickness (Men (n =173), Women (n=99))

Apart from blood glucose, HDL cholesterol and triglycerides, the central values were significantly higher for BMI, AFC, WC and total cholesterol in women.

3.3. Anthropometric and Biochemical Characteristics of the Study Population Free of Metabolic Disorders

Of the 506 participants, 119 subjects were free of metabolic disorders with: blood glucose ≥1.00 g/L (5.5 mmol/L), triglycerides ≥1.50 g/L (1.7 mmol/L), HDL cholesterol > 0.40 g/L (men) and > 0.50 g/L (women), and blood pressure < 130/85 mmHg. Table 2 presents the reference intervals between the 2.5th and 97.5th percentiles for some relevant parameters of cardiometabolic characteristics.

HDL cholesterol was significantly higher in women who were young adults, as were the men in the study. The upper limits of WC in men were 87 cm compared to 93 cm in women.

Table 2. *Anthropometric and biochemical characteristics of the population free of metabolic disease in the maritime region.*

Variable	MEN (n=68) Min	Max	2.5th Percentiles	97.5th Percentiles	Mean ± SD	WOMEN (n=51) Min	Max	2.5th Percentiles	97.5th Percentiles	Mean ± SD	*P value
Age (years)	17	59	17	53.3	23.9 ±10.2	16	56	17	47.3	23.3 ±9.5	0.7457
BMI (kg/m^2)	18.5	24.8	18.5	24.9	21.2 ±1.7	18.5	24.9	18.6	24.7	21.7±1.7	0.1054
TT (cm)	60	113	64	87	73 ±8	53	100	60	93	71 ±9	0.184
PCA* (mm)	7.2	29.8	7.4	27.3	14.74 ±6	8.8	25.6	10.42	24.7	17.7 ±4.3	0.1525
Blood glucose (g/l)	0.58	0.99	0.69	0.95	0.79 ±0.08	0.65	0.99	0.68	0.95	0.77 ±0.07	0.1287
T-Cholesterol (g/l)	0.95	2.48	1.08	2.30	1.67 ±0.32	1.17	2.51	1.24	2.35	1.73 ±0.29	0.2969
HDL cholesterol (g/l)	0.40	0.83	0.41	0.80	0.55 ±0.1	0.50	0.90	0.50	0.87	0.64 ±0.10	< 0.0001
Triglycerides (g/l)	0.34	1.35	0.36	1.21	0.66 ±0.22	0.29	1.22	0.37	1.11	0.62 ±0.23	0.5944

WC: Waist circumference (mean) ± SD (standard deviation): ACF: Abdominal skinfold (Men (n =13), Women (n=14))

3.4. Determination of Optimal Waist Circumference Thresholds Based on the Cardiometabolic Characteristics of Abdominal Obesity

The WC thresholds predictive of prediabetes, diabetes, dyslipidemia and hypertension, which characterize the accumulation of fat in the abdominal area, were determined in Tables 3 and 4 for women and men respectively. These thresholds correspond to the intersection points between the sensitivity and specificity curves, which allow a characteristic to be classified as positive.

Table 3. *Sensitivity and specificity of WC levels and WC thresholds associated with the presence of prediabetes, diabetes, dyslipidemia and hypertension in women.*

WC in cm	Blood glucose ≥ 1.00		Blood glucose ≥ 1.26		BP ≥ 130/85 mm Hg		Total cholesterol ≥ 2.0 g/l		Triglycerides ≥ 1.50 g/l	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
71.5	86	32	80	29	89	40	81	32	96	31
72.5	84	33	80	30	88	41	81	34	96	32
73.5	84	37	80	34	84	45	81	39	88	36
74.5	82	39	80	36	84	48	80	41	88	38
75.5	78	44	80	40	78	51	76	46	81	42
76.5	76	46	80	43	76	54	75	49	81	44
77.5	76	48	80	45	73	55	73	51	81	46
78.5	76	50	80	47	71	57	72	53	77	48
79.5	74	52	70	48	70	59	72	55	77	50
80.5	64	56	60	53	65	64	67	61	69	55
81.5	62	60	50	56	61	67	65	64	65	58
82.5	60	60	50	57	61	68	63	65	65	59
83.5	60	62	50	58	60	70	62	66	65	60
84.5	60	66	50	62	60	76	54	68	65	64
85.5	60	67	50	63	59	77	54	69	65	65
86.5	58	69	50	64	57	78	52	70	58	66
87.5	52	72	30	67	53	81	48	74	54	69
88.5	48	72	30	68	53	83	48	75	54	71
89.5	48	74	30	70	52	84	48	77	54	72
90.5	48	77	30	72	51	88	46	79	50	74
91.5	48	79	30	74	48	89	43	81	46	76
92.5	44	81	30	77	43	89	39	83	42	79
93.5	42	82	30	78	42	90	37	83	42	79
94.5	40	83	30	79	40	91	37	85	42	81
95.5	32	83	30	81	35	91	34	87	35	82
96.5	30	85	30	83	31	91	30	87	27	83
97.5	28	86	30	84	29	92	28	88	27	85
99.0	28	89	30	86	27	94	24	89	27	87
100.5	20	90	30	89	22	95	20	92	23	89

WC in cm	Blood glucose ≥ 1.00		Blood glucose ≥ 1.26		BP ≥ 130/85 mm Hg		Total cholesterol ≥ 2.0 g/l		Triglycerides ≥ 1.50 g/l	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
101.5	18	91	30	90	19	95	18	92	23	90
102.5	16	91	30	91	18	95	15	92	19	91
103.5	16	92	30	91	16	95	15	93	19	92
104.5	16	94	30	93	14	96	11	93	15	93
106.0	16	94	30	93	13	96	11	94	15	93
107.5	16	96	30	95	11	97	10	95	15	95
108.5	14	96	20	95	10	98	9	96	15	95
109.5	14	97	20	95	10	98	9	96	15	96
110.5	10	97	10	96	9	99	9	97	12	96
111.5	8	98	10	97	7	99	8	98	12	98
112.5	8	98	10	97	7	100	6	98	12	98
114.0	6	98	10	98	6	100	5	98	12	98
116.5	6	100	10	99	4	100	1	98	4	99
119.0	4	100	10	99	3	100	0	98	0	99
120.5	0	100	0	100	1	100	0	99	0	100
>120.5	0	100	0	100	0	100	0	100	0	100
Threshold value *	86		79		91		82		86	
AUC (95% CI)	66.17 (57.69-74.66)		59.24 (38.91-79.58)		72.9 (66.69-79.08)		66.55 (59.35-73.75)		68.91 (59.31-78.51)	
Number of characteristics present	50/268		10/268		108/268		79/268		26/268	
*P value	0.00		0.18		0.00		0.00		0.00	

AUC (Area Under the Curve) or the area under the curves showing the relationship between sensitivity and receptivity. AUC (95% CI): the area with a 95% confidence interval. An AUC with a lower confidence interval limit strictly above 50% indicates significant discriminatory capacity.

Table 4. *Sensitivity and specificity of WC levels and WC thresholds associated with the presence of prediabetes, diabetes, dyslipidemia and hypertension in men.*

WC in cm	Blood glucose ≥ 1.00		Blood glucose ≥ 1.26		BP ≥ 130/85 mm Hg		Total cholesterol ≥ 2.0 g/l		Triglycerides ≥ 1.50 g/l	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
70,5	86	38	100	36	67	36	74	37	100	38
71,5	79	42	100	40	63	40	72	42	90	42
72,5	79	50	100	48	55	47	65	49	86	50

WC in cm	Blood glucose ≥ 1.00		Blood glucose ≥ 1.26		BP ≥ 130/85 mm Hg		Total cholesterol ≥ 2.0 g/l		Triglycerides ≥ 1.50 g/l	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
73,5	72	56	100	55	50	55	61	56	76	56
74,5	66	61	75	59	44	59	61	62	62	59
75,5	55	68	75	67	37	66	57	70	62	68
76,5	55	71	75	70	35	70	54	73	62	71
77,5	52	75	63	73	31	73	54	78	62	75
78,5	48	76	50	74	28	74	52	79	57	76
79,5	48	77	50	75	28	75	52	80	57	77
80,5	45	78	50	76	27	76	50	81	52	78
81,5	45	79	50	77	26	78	50	83	52	79
82,5	45	81	50	79	24	79	46	83	48	80
83,5	41	82	50	80	22	80	41	84	48	82
84,5	41	85	50	83	21	84	35	86	48	85
85,5	38	88	50	86	17	86	35	89	43	87
86,5	34	89	38	87	17	88	30	90	43	88
87,5	31	89	38	87	17	88	30	90	43	89
89	31	89	38	88	17	89	30	91	43	90
91	31	91	38	90	16	91	26	92	38	91
92,5	31	92	38	90	16	93	24	93	38	92
93,5	31	93	38	91	15	93	24	93	38	93
94,5	31	93	38	91	15	93	24	94	38	93
95,5	28	96	38	94	9	94	20	96	38	96
98	17	97	25	96	7	96	17	98	29	97
100,5	14	97	25	96	7	97	15	98	29	98
101,5	10	97	25	97	6	97	13	98	24	98
103	7	97	13	97	5	97	13	99	19	98
104,5	3	97	13	97	5	98	11	99	14	98
106	3	98	13	98	5	99	9	99	10	98
108,5	3	98	13	98	5	99	7	99	10	99
110,5	0	99	0	99	2	99	4	99	10	100
112	0	99	0	99	1	99	2	99	5	100
>112	0	100	0	100	0	100	0	100	0	100
Threshold value *	73		74		93		82		71	
AUC (95% CI)	68,03 (56,67-79,38)		79,27 (68,8-91,74)		53,33 (45,65-61,02)		65,6 (55,92-75,34)		76,10 (66,07-86,14)	
Number of characteris-	29/238		8/238		86/238		46/238		21/238	

WC in cm	Blood glucose ≥ 1.00		Blood glucose ≥ 1.26		BP ≥ 130/85 mm Hg		Total cholesterol ≥ 2.0 g/l		Triglycerides ≥ 1.50 g/l	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
tics present										
*P value	0,01		0,01		0,05		0,00		0,00	

BP: Blood Pressure AUC (Area Under the Curve) or the area under the curves showing the relationship between sensitivity and receptivity. AUC (95% CI): the area with a 95% confidence interval. An AUC with a lower confidence interval limit strictly above 50% indicates significant discriminatory capacity.

Table 3 identified WC thresholds of 82, 86, 86 and 91 cm in women, respectively, which were significantly associated with the presence of the following cardiometabolic characteristics: Total cholesterol ≥ 2.0 g/l, Triglycerides ≥ 1.50 g/l, blood glucose ≥ 1.00 and BP ≥ 130/85 mm Hg. The optimal threshold selected was less than or equal to the upper limit (93 cm) of the WC reference range for subjects without any metabolic pathology, i.e., 91 cm.

Table 4 identified WC thresholds of 71, 73, 74, 82 and 93 cm in men, respectively, which were significantly associated with the presence of the following cardiometabolic characteristics: Triglyceridemia ≥ 1.50 g/l, Glycaemia ≥ 1.00 g/l, blood glucose ≥ 1.26 g/l, total cholesterol ≥ 2.0 g/l and T A ≥ 130/85 mm Hg. The optimal threshold selected was less than or equal to the upper limit (87 cm) of the WC reference range for subjects without any metabolic pathology, i.e. 82 cm.

4. Discussion

This study involved 581 adults aged 15 to 59, with a predominance of females. The [15-40[age group was the most represented, which corresponds to the demographic profile of Togo, characterized by a young population [10]. Within this category of young adults, a higher proportion of males was observed, which differs from the overall distribution of the sample. This sample is representative of the majority of the largest ethnic groups. The proportions of ethnic groups recruited versus those in the literature were: 57.9% Ewé/Mina vs 26.8%; Ouatchi 11.8% vs 10.0%; 11.5% Kabyè vs 14.7%; 5.7% Kotokoli/Tem vs 5.8% [11].

4.1. Metabolic Profiles

The average female BMI (26.37 kg/m^2) shows that the majority of young adul women under the age of 40 were overweight, unlike men. This result was confirmed by data from the 2021 WHO STEPS-TOGO survey, which found that 23.3% of women were overweight, compared to 14.7% of men [8]. The higher prevalence of overweight among women can be explained by lower levels of physical activity among women, combined with higher levels of sedentary behavior (HAS). In Africa, sociocultural factors such as social representations that value corpulence as a sign of wealth and good health encourage the desire to be overweight [19]. Although BMI is the most commonly used tool for documenting the risks associated with excess weight and for measuring changes in the prevalence of obesity at the population level, the addition of waist circumference refines these estimates by allowing the quantification of abdominal obesity or "at-risk" obesity [20].

The significant increase in average waist circumference among women in the general study population compared to men can be explained by physiological differences in the distribution of abdominal adiposity according to gender [21]. Furthermore, these observations are consistent with existing epidemiological data suggesting a tendency towards more pronounced abdominal adiposity in women, particularly after sexual maturation [22, 23]. Thus, according to the WC limits for diagnosing abdominal obesity according to the IFD, the majority of women would be considered obese, which is not the case for men. In women without any metabolic pathology, the average value was 71 cm, but when applying the SD, the upper limit rises to 80 cm. In addition, the upper limit of the WC reference range in women was 13 cm higher than the 80 cm limit specific to the Caucasian race [24]. These higher WC results in women may be due to the greater presence of abdominal adiposity in women. Indeed, the average ACF results were higher in women in the general population and in the population free of metabolic disorders. This anthropometric measurement, which directly quantifies subcutaneous adipose tissue, is an independent predictive marker of cardiometabolic risk [25]. Is this why the prevalence of cardiometabolic characteristics such as prediabetes (18.7% vs 12.2%), hypertension (40.3% vs 36.1%), and hypercholesterolemia (29.5% vs 19.3%) were higher in women of this study? In 2021, the STEPS survey also found a higher prevalence of hyperglycemia among women (5.3% vs. 4.4%) [8]. In 2015, a study conducted at the Hedzranawoe market in Togo showed a higher prevalence of metabolic syndrome in women (1.3% (Women) vs 0.8% (Men) [3].

4.2. Determination of Optimal Waist Circumference Thresholds

The study established specific waist circumference thresholds for Togolese people in the maritime region, which are predictive of cardiometabolic risks. These thresholds were determined using the Youden method, as was the case in 2006 in Tunisia by Bouguerra and his colleagues [9], and meet a need for data that is not available for Africa. In 2020, the study conducted by Ross and his colleague's provided values for each race and showed that BMI alone was no longer sufficient for predicting cardiometabolic risks. In the present study, the optimal thresholds determined for women and men of African origin residing in the maritime region of Togo were 91 cm and 82 cm, respectively [26].

The threshold of ≥91 cm for women in this study is higher than the thresholds established by the IDF and WHO for Caucasians, and higher than the threshold of 88 cm for African Americans and also used in Canada [20]. Among Iranians, the value of 91 was also established for women in 2009 [27]. The thresholds found in the Japanese (≥ 90 cm), Tunisian (≥85 cm) and Jordanian (≥96 cm) populations was all as in the present study, higher than the 80 cm recommended for sub-Saharan Africa [26]. For the male population, analysis of the data identified a threshold of 82 cm, which is lower than the 94 cm IDF recommended for sub-Saharan Africa by the WHO. All thresholds established for men by the Japanese and Tunisian (≥85 cm), Chinese (≥80 cm) and Iranian (≥89 cm) populationswere also below the 94 cm IDF threshold [9].

This study highlights a remarkable epidemiological paradox: despite higher prevalence of metabolic complications in women, ROC analysis suggests optimal waist circumference thresholds higher than those in men. According to Bouguerra et al., there is a correlation between waist circumference and visceral fat depending on gender and ethnicity [9]. Visceral fat differs from subcutaneous fat in its physiological role and impact on health. It produces cytokines, pro-inflammatory substances that disrupt metabolism, increase insulin resistance and promote atherosclerosis [28]. These effects are more pronounced in certain ethnic groups and also differ according to gender, which explains why waist circumference measurements should be interpreted taking into account the presence or absence of factors such as prediabetes, dyslipidemia and hypertension [29].

According to Wang et al., Asians have more subcutaneous fat than Caucasians [30], and in Japan, the waist circumference threshold is significantly higher in women (90 cm) than in men (85 cm) [9].

The heterogeneity of thresholds according to the parameters studied also highlights the complexity of the pathophysiological mechanisms linking abdominal obesity to the various components of metabolic syndrome. The INTERHEART study had previously shown that the association between waist circumference and cardiovascular risk varies according to the populations and risk factors considered [31, 32].

4.3. Strengths of the Study

This study has several important methodological strengths. The use of multiple metabolic reference criteria (hyperglycemia, diabetes, hypertension, dyslipidemia) allows for a comprehensive assessment of the diagnostic performance of waist circumference. The gender-differentiated approach, based on rigorous analysis of ROC curves and calculation of areas under the curve with their confidence intervals, represents a methodological advance over previous descriptive approaches. Although limited to the maritime region, the study population represents a significant sample of Togolese people (268 women and 238 men), allowing for robust statistical analyses.

4.4. Limitations of the Study

Although acceptable for a pilot study, the sample sizes remain relatively small for certain subgroups analyzed, particularly for the diabetic criterion in women (n=10) and men (n=8), generating wide confidence intervals and limiting the accuracy of the estimates. However, knowledge of the upper limit of the reference interval in subjects without metabolic disease made it possible to choose relevant and optimal thresholds.

4.5. Recommendations and Prospects

Although more than 80% of Togo's ethnic groups were recruited for this study, there is an urgent need to extend the study to the Plateau, Central, Kara and Savannah regions of Togo.

5. Conclusion

This study used a methodological approach based on ROC curve analysis to determine specific waist circumference thresholds for the diagnosis of abdominal obesity in the black population of the maritime region of Togo. The threshold of 91 cm in women avoids falsely declaring female subjects to be obese, especially if the patient is free of any metabolic pathology. It will prevent underdiagnosis of abdominal obesity in men using IDF criteria. It is important to note the existence of women without any metabolic disorders who have waist circumferences of up to 93 cm according to the 97.5th percentile analysis, confirming the need for contextualized interpretation.

Abbreviations

BMI	Body Mass Index
BP	Blood Pressure
CESP	Center for Research in Epidemiology and Population Health
CHO	Total Cholesterol
DAGL	Greater Lomé District
ESTBA	School of Biological and Food Technology
Gly	Glycemia
HAS	French National Authority for Health

HDL	High-Density Lipoprotein
INAM	National Health Insurance Institute
INSEED	National Institute of Statistics and Economic and Demographic Studies
INSERM	French National Institute of Health and Medical Research
ISO	International Organization for Standardization
LaSBASE	Laboratory of Biomedical, Agri-Food and Environmental Health Sciences
RGPH	General Census of Population and Housing
ROC	Receiver Operating Characteristic
STEPS	STEPwise Approach to Surveillance
TGL	Triglycerides
WC	Waist Circumference
WHO	World Health Organization

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Conflicts of Interest

The authors declare no conflicts of interest.

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