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Original Article

The complications of overweight and obesity according to obesity indicators (body mass index and waist circumference values) in a population of Tangier (northern Morocco): A cross-sectional study

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ABSTRACT

Aim: The aim of this work was to study overweight and obesity and their associated complications according to obesity indicators in a population of Tangier.
Methods: A total of 480 overweight and obese patients were included in this study, referred to hospital Duc Tovar of Tangier during a period of 12 months. The collection of data has been done through a questionnaire which included anthropometric, clinical and biochemical characteristics of each patient. Statistical analyses included chi2 test, student's t-test, ANOVA, and multiple linear regression analyses.
Results: The mean age of our patients was 45.56 ± 12.23 years, the mean body mass index (BMI) was $33.97 \pm 5.84\ Kg/m^2$ and the average waist circumference (WC) was 109.78 ± 15.42 cm. Overweight affected 25.2% and obesity 74.8%, whose 88.8% of subjects had abdominal obesity. All the metabolic abnormalities were significantly associated with abdominal obesity (measured by WC). However, only total cholesterol ($p=0.001$) and triglycerides ($p=0.000$) were significantly associated with different classes of obesity (measured by BMI).
The most common complications of obesity and overweight were: type 2 diabetes (56.8%), arterial hypertension (52%), dyslipidaemia (43.9%), and cardiovascular disease (CVD) (24.3%). Hypertension and hyperglycaemia were the major risk factors for developing CVD with OR = 3.81 (95% CI:1.363–10.698; $p < 0.05$) and OR = 2.610 (95% CI:1.648–4.133; $p < 0.001$) respectively.
Conclusion: Obesity exposes to several chronic complications, the most important in our study were type 2 diabetes and hypertension; these complications increased significantly with abdominal obesity that has constituted important risk factors of CVD.

1. Introduction

Currently, obesity is considered to be the first non-infectious inflammatory disease in human history. According to WHO, overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health [1].

The prevalence of obesity is increasing worldwide. From 1980 to 2014, the global prevalence of obesity has more than doubled. In 2014, approximately 13% of the global adult population were obese on average; the prevalence was higher in women than men (11% and 15% respectively) [2]. In Morocco, the prevalence of obesity increased from 15.2% in 2005 to 20.6% in 2014 [2]. This growing prevalence of obesity in recent years is mainly due to changes in lifestyle, characterized by an increase in energy intake and a decrease in physical activity [3,4]. Overweight and obesity are major risk factors for several chronic diseases, including diabetes, cardiovascular disease and cancer [5–7].

Obesity studies were conducted in different regions of Morocco [8–11], but our study is the first in the northern region. In addition, our study is the first to study the complications of obesity in relation to its different classes (according to the values of BMI) and its different types (according to the values of the waist circumference). In this sense, we conducted a cross-sectional epidemiological study

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aimed to examine obesity in an adult population in the city of Tangier and the various complications associated with this pathology.

2. Subjects

In the present study, a total of 480 obese and overweight subjects were recruited in the endocrinology department at the hospital Duc Tovar of Tangier during a period of 12 months (between April 2016 and April 2017).

These subjects were selected according to a specific questionnaire that included: age, BMI, waist circumference (WC), blood pressure, biochemical measurements (total cholesterol (TC), HDL cholesterol (HDLc), LDL cholesterol (LDLc), Triglycerides (Trig), fasting glucose and glycated haemoglobin (HBA1c)), as well as other clinical data of patients.

Inclusion criteria/exclusion criteria

Overweight or obese adults aged 18–64 years were recruited into the study.

Individuals were excluded from this study if they were pregnant, physically disabled, had normal weight and not consent to participate in the study.

3. Materials and methods

3.1. Anthropometry

The body weight was measured with an accuracy of 0.1 kg by a battery-operated digital balance and the waist circumference was measured by a metric tape measure. BMI was calculated by the following formula: BMI = weight (kg)/height2 (m2). Waist circumference was measured at the approximate midpoint between the lower margin of the last palpable rib and the top of the iliac crest with a flexible tape measure that is not elastic.

Obesity was defined for a BMI> 30 kg/m^2 with three classes: obesity class I (BMI between 30 and 35 Kg/m^2), obesity class II (BMI between 35 and 40 Kg/m^2) and obesity class III (BMI $\geq$40 Kg/m^2); overweight for a BMI between 25 and 30 Kg/m^2. Abdominal obesity was defined by waist circumference >88 cm for women and 102 cm for men.

3.2. Biochemical analysis and clinical parameters

Fasting blood glucose (FBG) was determined by the glucose oxidase enzymatic method, and glycated haemoglobin (HBA1c) was assessed by Bio-Rad Variant II HPLC system. The diagnostic criteria for diabetes were a fasting plasma glucose value $\geq$ 1.26 g/l or Hb1Ac $\geq$6.5%. Enzymatic colorimetric tests were used to measure TC and Trig. HDL-C was measured by a homogenous enzymatic colorimetric test (PEG cholesterol esterase, and PEG peroxidase), LDL cholesterol concentrations were calculated using the Friedewald formula. All biochemical analyses of serum lipids were performed using a Hitachi 737 analyser. Patients with untreated total cholesterol>1.94 g/l (5.0 mmol/l), TG > 1.5 g/l (1.7 mmol/l) and/or HDL-C <0.4 g/l (1.03 mmol/l) in males and <0.50 g/l (1.29 mmol/l) in females were considered dyslipidemic according to the US National Cholesterol Education Program Adult Treatment Panel (NCEP ATP) III [12].

The blood pressure was measured using an electronic blood pressure monitor. The measuring conditions comply with WHO recommendations [13]. A high blood pressure was defined as a systolic blood pressure (SBP) > 139 mmHg and/or a diastolic blood pressure (DBP) > 89 mmHg according the Eighth Joint National Committee on the Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 8) [14].

The cardiovascular diseases comprising all diseases or syndromes that were considered to be clinically significant forms of cardiovascular disease such as coronary heart disease (CHD) that includes myocardial infarction, unstable/stable angina, coronary artery procedures (angioplasty or bypass surgery) or evidence of clinically significant myocardial ischemia.

3.3. Statistical treatment of data

Continuous variables (biochemical data) were expressed as means ± standard deviation; and categorical variables (clinical data) are presented as absolute and relative frequencies.

To compare quantitative parameters that follow a normal distribution we used Student's t-test and ANOVA, as appropriate. Otherwise, Mann-Withney *U* test was applied for non-normally distributed quantitative trait. Chi squared tests were used for categorical variables. Odds ratios (OR) with 95% of confidence intervals (CI) were obtained by multivariate logistic regression analyses. P-values that are less than 0.05 were considered as statistically significant.

Statistical analyses were performed using SPSS statistical software package version 21.

3.4. Ethical consideration

The study was approved by the Tanger-Aassilah health delegation and registered under the number: 6223. All participants gave written informed consent before including them in this study. Anonymity and confidentiality were ensured.

4. Results

4.1. Anthropometric and biochemical characteristics of the study population

It was a descriptive cross-sectional study that have focused on obese and overweight subjects of mean age 45.56 ± 12.23years with a female predominance: 83% of women versus 17% of men. Anthropometric parameters and biochemical data of the study population has reported in Table 1.

Some anthropometric, biochemical and clinical features showed significant differences between men and women. Men were found to have a higher level of triglycerides (p=0.04) and lower level of HDL(p=0.01) than women, whereas women showed higher BMI (p=0.004) than men (Table 1).

The distribution of patients according to BMI showed that obesity of class I was the most manifest with 40.7% cases and 15% had morbid obesity. Also, the distribution of obese patients according to waist circumference values showed that 88.8% of them had abdominal obesity (Table 2).

Analyses showed that obesity negatively changes the metabolic profile of obese patients (increased level of: fasting blood glucose, triglycerides, LDL cholesterol and total cholesterol and a decrease level of HDL cholesterol). As expected, the mean of all metabolic abnormalities increased with abdominal obesity especially glycated hemoglobin (p = .001), LDL-cholesterol (p = .001), total cholesterol (TC) (p = .006), and triglycerides cholesterol (Trig) (p = .011) (Table 2). In addition, Trig, TC, and LDL-cholesterol were positively correlated with waist circumference values (r = 0.269 p < .0001, r = 0.245 p < .0001 and r = 0.322 p < .0001respectively) and HDL-cholesterol levels were negatively correlated with waist circumference (r = -0.322, p < .0001). However, just total cholesterol and triglycerides increased significantly with different classes of obesity

Table 1
Anthropometric and metabolic characteristics of the study population.

Parameters	Total (N = 480) Average ± SD 95%(CI)	Men (N = 80) Average ± SD 95%(CI)	Women (N = 400) Average ± SD 95%(CI)	P-value *
Age (years)	45.56 ± 12.234 (44.46–46.65)	46.66 ± 12.182 (43.95–49.37)	45.34 ± 12.247 (44.13–46.54)	0.376
BMI (kg/m^2)	33.97 ± 5.84 (33.45–34.49)	32.2640 ± 4.70833 (31.2162–33.3117)	34.3169 ± 5.99030 (33.7281–34.9)	0.004
WC (cm)	109.78 ± 15.426 (108.40–111.16)	109.50 ± 14.385 (106.30–112.70)	109.84 ± 15.643 (108.30–111.38)	0.858
SBP (mmHg)	138.85 ± 51.257 (134.25–143.44)	138.68 ± 19.252 (134.39–142.96)	138.88 ± 55.503 (133.43–144.34)	0.974
DBP (mmHg)	82.09 ± 30.362 (79.36–84.81)	82.33 ± 7.617 (80.63–84.02)	82.04 ± 33.094 (78.78–85.29)	0.938
FBG (g/L)	(1.5960 ± .85755) (1.5191–1.6729)	(1.6404 ± .82926) (1.4558–1.8249)	(1.5871 ± .86384) (1.5022–1.6720)	0.612
TC(g/L)	1.9678 ± .55054 (1.9184–2.0172)	1.9625 ± .50316 (1.8505–2.0745)	1.9689 ± .56012 (1.9138–2.0239)	0.925
HDLc (g/L)	.4910 ± .13355 (.4790-.5030)	.4469 ± .10827 (.4228–4710)	.4999 ± .13646 (.4864-.5133)	0.01
Trig (g/L)	1.5515 ± .65496 (1.4928–1.6103)	1.6773 ± .74955 (1.5104–1.8441)	1.5264 ± .63241 (1.4642–1.5885)	0.04
HBA1c (%)	7.08842 ± .49298 (6.8649–7.3120)	7.0304 ± 1.25351 (6.7514–7.3093)	7.1001 ± 2.67379 (6.8372–7.3629)	0.820
LDLc	1.15 ± 0.55 (1.10–1.20)	1.16 ± 0.49 (1.05–1.27)	1.15 ± 0.56 1.09-1.20	0.474

Data are presented as mean ± SD and 95% confidence interval (CI). BMI. body mass index; DBP, diastolic blood pressure; FBG, Fasting blood glucose; HDL, high-density lipoprotein; HBA1c, glycated hemoglobin; LDL, low-density lipoprotein; SBP, systolic blood pressure; SD, standard deviation; TC, Total cholesterol; Trig, Triglycerides; WC, waist circumference. *P was used for comparison between men and women.

Table 2
Clinical and biochemical data of the study population according to BMI and waist circumference (WC) values.

Parameters	Overweight[a] N = 121 % = 25.2	Class I[b] N = 196 % = 40.7	Class II[c] N = 91 % = 18.9	Class III[d] N = 72 % = 15		Abdominal obesity[e] N = 426 % = 88.8	Non- abdominal obesity[f] N = 54 % = 11.2	Total N = 480 % = 100	
	mean± SD	**mean± SD**	**mean± SD**	**mean± SD**	***p*-value**	**mean± SD**	**mean± SD**	**mean± SD**	***p*-value**
HBA1c (%)	6.9469 ± 1.67	7.03 ± 1.42	7.28 ± 4.79	7.23 ± 1.55	.397	7.1103 ± 2.60	6.91 ± 1.37	7.08 ± 2.49	.001
FBG(g/l)	1.60 ± 0.98	1.70 ± 0.92	1.38 ± 0.58	1.54 ± 0.67	.000	1.56 ± .83	1.85 ± .0002	1.59 ± .85	.021
Trig(g/l)	1.31 ± .44	1.65 ± 0.56	1.60 ± 0.7	1.90 ± .87	.000	1.56 ± .67	1.40 ± .41	1.55 ± .65	.011
TC(g/l)	1.75 ± 0.42	1.98 ± .050	1.97 ± 0.54	2.26 ± 0.69	.001	1.99 ± .56	1.78 ± .42	1.96 ± .55	.006
HDLc (g/l)	0.50 ± 0.10	0.44 ± 0.11	0.43 ± 0.11	0.36 ± 0.11	.341	.4890 ± .13	.5070 ± .12	.4910 ± .13	.024
LDL(g/l)	0.9 ± 0.42	1.16 ± 0.51	1.18 ± 0.52	1.51 ± 0.68	0.000	1.17 ± 0.56	0.97 ± 0.43	1.15 ± 0.55	0.01
SBP (mmHg)	132.60 ± 20.12	135.90 ± 21.61	150.69 ± 108	142.39 ± 21.27	.119	139.71 ± 53.98	132.06 ± 17.93	138.85 ± 51.25	.275
DBPmmHg)	79.88 ± 80.8	83.80 ± 46.29	81.40 ± 8.85	82.01 ± 9.24	.623	82.36 ± 32.14	79.93 ± 6.53	82.09 ± 30.36	.535

Data are presented as Frequency (N) and percentage (%) or mean ± SD. FBG, Fasting blood glucose; HDL, high-density lipoprotein; HBA1c, glycated hemoglobin; LDL, low-density lipoprotein; SD, standard deviation; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, Total cholesterol; Trig, Triglycerides.
[a] Overweight: 25 ≤ BMI <30.
[b] Class I obesity:30 ≤ BMI <35.
[c] Class II obesity:35 ≤ BMI <40.
[d] Class III obesity: BMI ≥40.
[e] Abdominal type obesity: Men WC > 102 cm, Women WC > 88 cm.
[f] non-abdominal obesity: Men WC < 102 cm, Women WC < 88 cm.

(p=0.001 and p=0.000 respectively) (Table 2).

4.2. Complications of obesity in the study population

Obesity and overweight are responsible of developing several complications. The presented study is more interested in metabolic complications that are most manifested in our patients such as type 2 diabetes (56.8%), hypertension (52%), dyslipidaemia (43.9%), and CVD (24.3%) (Table 3).

The statistical analyses showed that compared to subjects with overweight, those with BMI≥30 kg were more likely to have diabetes (odds ratio (OR) = 1.62; 95% confidence interval (CI): 1.07–2.45) and dyslipidaemia (OR = 1.81; 95% CI: 1.58–2.07); whereas, abdominal obesity was associated significantly with a higher risk of dyslipidaemia (OR = 2. 95% CI:1.08–3.70) and hypertension (OR = 1.82; 95% CI: 1.023–3.26) in comparing with non-abdominal obesity (OR = 0.64; 95% CI:0.42–0.98 and OR = 0.72; 95% CI:0.51–1.02; for dyslipidaemia and hypertension respectively)

Table 3
The risk of metabolic complications according to the BMI and waist circumference values.

	Overweight[a] N = 121 OR (95%CI)	Obesity[b] N = 359 OR (95%CI)	*p*-value	Abdominal obesity[c] N = 426 OR (95%CI)	Non- abdominal obesity[d] N = 54 OR (95%CI)	*p*-value
Diabetes N = 273(56.8%)	0.80 (0.65–0.98)	1.62 (1.07–2.45)	0.014	1.04 (0.82–1.32)	0.89 (0.50–1.59)	0.41
Dyslipidaemias N = 211(43.9%)	0.16 (0.09–0.27)	1.81 (1.58–2.07)	0.000	2.0 (1.08–3.70)	0.64 (0.42–0.98)	0.016
Hypertension N = 250(52%)	0.85 (0.691–1.061)	1.36 (0.903–2.063)	0.085	1.82 (1.02–3.26)	0.72 (0.51–1.02)	0.028
CVD N = 117(24.3%)	0.92 (0.56–1.49)	1.020 (0.90–1.14)	0.419	1.335 (0.86–2.05)	0.672 (0.36–1.24)	0.13

Data are presented as Frequency (N) and percentage (%) or odds ratio (95% confidence interval). CVD: cardiovascular disease.
[a] Overweight: 25 ≤ BMI <30.
[b] Obesity: BMI≥ 30.
[c] Abdominal obesity: Men WC > 102 cm, Women WC > 88 cm.
[d] Non-abdominal obesity: Men WC < 102 cm, Women WC < 88 cm.

(Table 3).

These metabolic abnormalities themselves constituted risk factors for CVD. In fact, the major risk factors for CVD were hypertension (18.3%) (OR = 3.81; 95% CI:1.363–10.698; p -value< 0.05) and diabetes (17.9%) (OR = 2.610; 95% CI:1.648–4.133; p -value <0.000).

However, there were patients who had two risk factors (18.7%) or three risk factors (10%). (Fig. 1).

5. Discussion

The prevalence of obesity in this study was higher among females (83% of women and 17% of men). This widespread presence of obesity among females was confirmed by several studies [15–17], and it was due to biological reasons that promote obesity in women, such as pregnancy and menopause because of major hormonal changes [11,18]. As well as, the key period in the development of obesity among girls was the transition period from adolescence to adulthood [18].

Our study showed that 25.2% of the studied subjects were overweight, and 74.8% were obese. These results are close to those found in a study of an obese population in Benin who had a mean age of 51.43 years with 19% overweight and 81% obese [19], also almost the same prevalence of overweight has been find in a Nigerian population (23.3%) [20].

On the other hand, we have noticed that obesity negatively changes the metabolic profile of overweight and obese patients. In fact, the mean values of metabolic abnormalities increased significatively with abdominal obesity more than with BMI classes with a significant increase in glycated haemoglobin ($p = .001$), LDL-cholesterol ($p = .001$), total cholesterol($p = .006$) and triglycerides cholesterol($p = .011$). These results are in accordance with another study that have shown that the most common metabolic abnormalities of abdominal obesity were hyperglycaemia, increased triglycerides, and decreased HDL_c [21]. In fact, previous study has provided that waist circumference is a better marker of abdominal fat accumulation than the body mass index. Abdominal obesity is a marker of a dysmetabolic state, it is a predictive of insulin resistance and presence of related metabolic abnormalities [22]. In addition, all lipid abnormalities were significantly correlated with the WC values, this association has been documented by several studies [23–25].

Regarding the complications of obesity in the studied population, the results of our study have revealed a certain number of metabolic complications:

- Diabetes affected 56.8% of the obese patients; these results find their matching compared to a studied population in Benin where the average age was of 51.43 ± 12.78 years, and with a percentage of 71% of obese patients suffering from diabetes [19]. This could be explained by the clinical features of the two populations that are already obese. In addition, both populations have almost the same mean age. These features are most frequently cited as important determinants in the onset of diabetes in obese patients. Additionally, the proposed study showed a significant link between the class of obesity and the risk of type 2 diabetes in the studied population. This shows a high agreement with results of previous studies, which have proven that the risk of diabetes is less comparing 22 kg/m^2 to 35 kg/m^2 [26]. Furthermore, the defining metabolic changes in obesity are decreased glucose tolerance, decreased sensitivity to insulin and hyperinsulinemia [21].
- The prevalence of dyslipidaemia was 43.9% in the study population. This prevalence is comparable with 40.7% found in Nigeria [27]. In addition, the risk of dyslipidaemia in the studied population was significantly associated with abdominal obesity and BMI values. This confirms the results found in the literature which state that obesity negatively modifies the lipid profile and that abdominal obesity is associated with a significant increase in triglyceride and total cholesterol levels [24,25].
- Our results showed a prevalence of hypertension of 47%, this result is consistent with results from Nigerian study, where the prevalence of hypertension was 43.9% [27]. However, these results are slightly lower than those found in a recent Moroccan study carried out on a population of the city of Fes with a mean age of 57 years with a prevalence of 66% [28], and much higher than those of a study carried out at the West of Cameroon on rural women aged 20–46 with a prevalence of 3.3% [29], what can be explained by the permanent practice of field work by these rural women which is a factor of prevention from the installation of arterial hypertension, contrary to the urban lifestyle which has become more sedentary.

On the other hand, analyses showed that the risk of hypertension was strongly related to abdominal obesity (according the value of waist circumference). A Nigerian study has demonstrated that increased WC was strongly associated with hypertension [27]. In addition, different studies have shown that regardless of age and BMI, high blood pressure was found to be associated with abdominal obesity [2,30].

- Regarding cardiovascular diseases, we found a prevalence of 24.3%; this prevalence is higher to that reported by a study carried out on a Tunisian population of average age 35.5 ± 21.98 years with a percentage of 15.5% [31]. These results can be explained by the difference in mean age between the two populations, which plays an important role in the occurrence of cardiovascular disease. Therefore, obesity considered to be a real risk factor for CVD, which has been already proven by several studies [32–34]. Also, reported that an increased WC value, as a marker of the relative amount of abdominal fat, was actually associated with a significant increased risk of myocardial infarction [35].

The analysis was demonstrated that the major risk factor for CVD were hypertension and diabetes with OR = 3.81 (95% CI:1.363–10.698; p -value< 0.05) and OR = 2.610 (95% CI:1.648–4.133; p -value <0.001) respectively. A previous study has

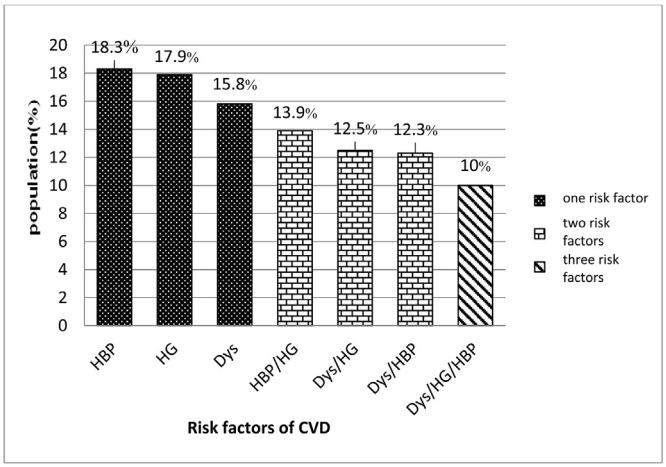

Fig. 1. Distribution of multiple metabolic risk factors of CVD.
Abbreviations: CVD: cardiovascular disease, Dys: dyslipidaemia, HG: hyperglycaemia, HBP: high blood pressure.

found that the incidence of cardiovascular disease, is higher in diabetic than in nondiabetic men and women [36]. Similar findings were seen in another study that has showed that hypertension and diabetes contribute to high prevalence of CVD [37].

6. Conclusion

Our study supposed to be the first in the North of Morocco that put into study the epidemiological, metabolic and clinical profile of overweight and obese patients, along with the complications of overweight and obesity according to the BMI and waist circumference values.

Obtained results have proved that obesity negatively changes the metabolic profile of obese patients and is responsible for development of several metabolic complications, such as hyperglycaemia, dyslipidaemia, and high blood pressure; these metabolic abnormalities had a significant increase specially with abdominal obesity. The Metabolic complications showed in our study increase the risk of the development of cardiovascular diseases, specially the hypertension and type 2 diabetes. Health education on healthy lifestyles is recommended to combat the obesity epidemic in the Tangier society.

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

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