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**Original Article**

# Abdominal Fat at CT-Scan and Cardiometabolic Risk in a Group of Cameroonian Women

## *Adiposité abdominale au scanner et risque cardiométabolique dans un groupe de femmes camerounaises*

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**ABSTRACT**

**Background**. The waist circumference is the most widely used determinant of abdominal fat. However, it is not very accurate, and cannot help us differentiate subcutaneous fat from visceral fat, which is known to be correlated with cardio-metabolic risk. The gold standard for this evaluating remains CT scan but is difficult to access in our context, due to the cost. The aim of the study was to assess the relationship between the different fat tissue layers of the abdomen, measured clinically and by CT-scans, with the cardio-metabolic risk, in order to detect the best measurement correlated with the cardio metabolic risk in Cameroonian women **Patients and Methods**. We performed a cross-sectional analytical study, from September 2010 to February 2011 at the Yaoundé Central Hospital. Our study population was made up of women without diabetes, stratified according to their body mass index. We looked at socio-demographic data, waist circumference, CT-scan fat measurements, insulin sensitivity and their correlation. We enrolled 48 women. **Results**. Their average age was 28 ± 6 years, BMI was 28kg / m2 [19-39]. Obese had higher abdominal adiposity with an average waist circumference of 107 ± 7cm and total fat at CT scan of 698 ± 98cm. Our population had poor insulin tolerance assessed using the KITT short insulin tolerance test with an average of 1.69 %/min. It was not correlated with waist circumference p = 0.056 r = 0.278 but was correlated with CT scan fat measurements p = 0.032 r = 0.310, more precisely with visceral fat p = 0.009 r = 0.375. **Conclusion**. This study confirm that visceral abdominal fat is better correlated with insulin sensitivity than subcutaneous fat and that waist circumference is not a reliable reflection of cardiometabolic risk.

**RÉSUMÉ**

**Introduction**. Le tour de taille est le déterminant de l'adiposité abdominale le plus utilisé. Cependant, il ne reflète pas l'adiposité viscérale étant mieux corrélée à l'insulinorésistance donc au risque cardiométabolique. Le scanner, le gold standard pour l'évaluer, est financièrement peu accessible dans notre contexte. Le but du travail était d'évaluer la relation entre les compartiments graisseux mesurés cliniquement et à l'aide du scanner abdominal et le risque cardiométabolique chez un groupe de femmes camerounaises. **Patients et méthodes**. Nous avons donc réalisé une étude analytique transversale, de septembre 2010 à février 2011 à l'Hôpital Central de Yaoundé. **Résultats.** Nous avons recruté 48 femmes non diabétiques, évaluées selon leur indice de masse corporelle. Nous avons examiné les données sociodémographiques, les paramètres vitaux, anthropométriques comme le tour de taille, l'adiposité scanographique, la sensibilité à l'insuline et leur corrélation. Leur âge moyen était de 28 ± 6 ans, IMC de 28 kg/m2. Les obèses avaient une adiposité abdominale plus élevée avec un tour de taille moyen de 107 ± 7 cm, une adiposité totale scanographique de 698 ± 98 cm. La sensibilité à l'insuline évaluée par le test court de tolérance à l'insuline ITT était faible (1,69 %/min) ; non corrélée au tour de taille p = 0,056 r = 0,278 mais à l'adiposité abdominale scanographique p = 0,032 r = 0,310 fortement à la viscérale p = 0,009 r = 0,375. **Conclusion**. Cette étude confirme que la graisse abdominale viscérale est mieux corrélée aux risque cardiométabolique que la sous-cutanée abdominale et le tour de taille qui n'est pas un reflet réel du risque cardiométabolique dans un contexte ou l'accès au scanner est financièrement limité.

## INTRODUCTION

Cardiovascular diseases are the leading cause of death in the world[1]. Obesity, one of the main cardiovascular risk factors is considered an epidemic, and is estimated that at least 400 million persons in the world are affected according to the WHO[1]. There is a surge in Low and middle-income countries in recent years, and Cameroon is not spared with a prevalence of around 50% among women against 31% among men[2]. Obesity is a major medical problem due to the cardiovascular and metabolic risk it induces[3]. More than total adiposity, the distribution of adiposity would determine cardiovascular risk, particularly abdominal adiposity truly related to insulin resistance[4]. However, waist circumference may not effectively reflect abdominal adiposity, unlike CT-scan measurement, given

that CT-scan and MRI are the gold standards for quantifying adipose tissue[5]. Based on these considerations, we decided to conduct this study to assess the relationship between the different fat tissue layers of the abdomen, measured clinically and by CT-scans, with the cardio-metabolic risk, in order to detect the best measurement correlated with the cardio metabolic risk in Cameroonian women.

## PATIENTS AND METHODS

We conducted an analytical cross-sectional study. The study population was made-up of women of childbearing age recruited in Yaoundé. The data were collected at the National Obesity Center and the radiology department of the Yaoundé Central Hospital. This study was carried out over a period of 6 months. Approval from the Cameroon National Ethics Committee was obtained prior to the beginning of the study. All participants provided written inform consent before any trial-specific procedures were performed.The variables studied: Dependent: insulin sensitivity, fasting blood sugar, blood pressure, lipid profile. Independent : age, BMI, total abdominal, subcutaneous and visceral adiposity.

### Procedure

*Invitation*

Eligible participants, were woman of reproductive age in good health regardless of their BMI. Were excluded any pregnant or breastfeeding woman, any known history of ascites, diabetes, having history of an infection of less than 3 weeks or under medication (oral contraceptives, corticosteroid, etc), any recent change in the level of physical activity. They were selected among association meeting, mouth to mouth communication. A total of seventy-one people were invited to take part in this study. This invitation was made verbally to all those who physically met the criteria; we informed the potential volunteers of the study, its procedures, and an appointment was schedule through a phone call for the inclusion visit. At arrival on the research site, urine was collected for a pregnancy test, as pregnancy was some exclusion criteria.

*Selection*

On the day of the invitation, participants were communicated the results of the rapid pregnancy test. This screening visit was carried out to verify that the volunteers met the various inclusion criteria defined above. An information and informed consent form were presented and read carefully by the volunteers.

Inclusion visit. The day before the inclusion visit, the physical activity and diet of the volunteers were standardized, in order to limit inter-individual variations linked to exogenous factors during the tests. On the day of the inclusion visit, participants arrived at 7:30 am.

We realised:

- An interview using a pre-established questionnaire
- We the following data during physical examination (anthropometric, vital parameters, with measurement total adiposity, skin folds ...)
- After physical examination, all inclusion and exclusion criteria were assessed, and an appointment was schedule for participants fulfilling all the inclusion criterias.

*Exploration visit*

On the day of the explorations, the participants arrived at the site research at 7:30 a.m., in a fasting state since 10 p.m. the previous day and amended of all physical activities. This was to limit any inter-individual variations during the tests linked to external factors. The inclusion and exclusion criteria were re-checked.

The exploration visit took place at the NCO (National Center of Obesity) and in the radiology department over 2 days. Before the beginning of each phase, a fasting blood glucose was taken. If hyperglycemia (glycemia > 1.26 g / l) was detected, the participant was excluded from the study and transferred to the NCO (National Center of Obesity).

■ **On day 1**:

This day was marked, by the realization of fasting blood sugar, with indirect measurements of total fat tissue by bio-impedancemetry and subcutaneous fat by measurement of skin folds by an adiposometer.

Five ml of venous blood was taken for blood glucose and lipid profile assay.

■ **On day 2:**

This day was marked by:

-Assessment of insulin sensitivity by the short insulin tolerance test:

The short insulin tolerance test (ITT) directly assessed insulin sensitivity through changes in blood sugar levels capillaries every 3 minutes supposed to regress in a certain way and at a certain speed, after injection of a supra-physiological dose of insulin intravenously. Its duration was 15 minutes in order to avoid hypoglycemia, the main complication of this test if carried out over a prolonged period.

-*The CT-scan*:

The volunteers were taken to the radiology department where abdominal and mid-thigh CT sections were made.

*Data collection, analysis and presentation*:

Data was collected during the clinical examination and then during the explorations using a pre-established questionnaire.

**Clinical examination:**

The questionnaire was carried out using a pre-established questionnaire. For each subject we insisted on the age in years, the sex, the date of the last menstruation (DDR), the past history of trauma, infection, corticosteroid intake, current infection, the general profile of the volunteer. Confidential, coded information kept secret in a database only accessible by our team.

**Physical examination:**

A general physical examination was performed. It consisted of taking anthropometric parameters, examining each system; The anthropometric parameters were evaluated by the same investigator, previously trained:

• Weight in kilograms

The scale adjusted to 0 kg before each measurement, the patient dressed in light clothes and thin socks and after emptying her bladder, stood in the middle of the scale. His weight in kilograms was noted to the nearest 0.5 kilogram.

• The Height

The subject was placed upright, with his back against the vertical base of the board, heels together, toes of the feet slightly apart to allow an even distribution of the weight on both legs. The arms hanging freely on either side of the trunk, the palms facing the thighs, occiput, shoulders, buttocks and calves touched the vertical base of the board. The sliding board of the measuring rod (wooden measuring rod graduated to within 0.5 cm) allowing the upper mark to be located.

• Body mass index (BMI)

The BMI was obtained by dividing the weight expressed in kilograms by the square of the height expressed in meters (kg / m2). Subjects with a BMI> 30 were considered obese.

• The hip circumference

Using a tape measure, we measured the hip circumference to the nearest cm at the height of the greater trochanter. After measuring the waist circumference, we deduced the waist circumference / hip circumference ratio (WC / HC) for each volunteer.

• Body composition / Bio impedancemetry

We indirectly measured total adiposity using a calibrated monitor held by the subject standing perpendicular to the body (TANITA®, TANITA corporation 1-14-2 Maeno-cho, Tabashi-Ku, Tokyo-Japan).

• Waist circumference

It was measured with a tape measure in the subject standing in exhalation, at the midpoint of the distance on the mid-axillary line between the top of the iliac crest and the inferior costal margin expressed to the nearest cm.

**CT-Scan procedures**

We directly measured abdominal adiposity using a SIEMENS SOMATOM Emotion Duo CT 2006 Scanner. The patients were coded in order to preserve their anonymity. An extended topogram was made from the xiphoid to the height of the knees.

- We performed a cut at the tenth to twelfth thoracic vertebrae to get a picture of the liver.
- Two cuts at the fourth and fifth lumbar vertebrae or at the umbilical level were performed (except in cases of abdominal obesity where it was quite difficult to locate the level of the umbilicus). The acquisition parameters were:
- 110 kV; 240 mA
- the viewing window: 40 for the center and 350 for the viewing width
- the acquisition time did not exceed 6 minutes
- the PDL irradiation (Product Dose Length) was 61 mGray (Ribeiro-Filho et al., 2003), we measured the fat surface using the automated functionality and the pixel measurement ranged from -130 to -90 Hounsfield units.

**Laboratory Procedures**

Cardiometabolic risk assessment:

• Assessment of insulin sensitivity by the short insulin tolerance test: ITT

Preparation of insulin:

Withdrawal of 0.15 U of rapid insulin per kilogram of body weight.

Procedure:

H0: Direct intravenous injection of 0.15 U of rapid insulin / kg body weight after disinfection of the injection site with alcohol cotton wool.

Min 3: 3 minutes after the injection, take a capillary blood glucose. So on every 03 minutes until the 15th minute which will mark the last blood sugar level.

Min 16: meal with a very high glycemic index in order to avoid rapid hypoglycemia due to the continuous action of the given insulin.

Min 30: taking a post-prandial capillary blood glucose level as a preventive measure (hypoglycemia)

END OF TEST. Then we had calculated the constant of glycemic decay in %/min: KITT

• Lipid profile:

We assayed the lipid profile in the laboratory of the Central Hospital of Yaoundé, by enzymatic method for total cholesterol, HDL cholesterol, triglycerides. The assay method was colorimetric. LDL cholesterol was calculated by Friedwald's formula:

Calculated LDL = Total Cholesterol-HDL Cholesterol - Triglycerides / 5 (The unit of measure here is g / L).

We considered for the metabolic syndrome hypo HDLemia fasting 0.5g / L and hyper TGmia 1.5 g / L

**Statistical analysis**

**Sample size**: A convenience sample stratified by sex and BMI was used and subjects were divided into three groups: subjects of normal weight (BMI between 18.5 and 24.9 kg / m2), overweight (BMI between 25 and 29.9 kg / m2) and obese (BMI greater than or equal to 30 kg / m2), female and of childbearing age. In order to demonstrate a difference in insulin sensitivity of 20% between obese and non-obese subjects, taking as a reference value the sensitivity to insulin M + or - 14.4 mg / kg / min. This resulted in a sample size of 11 similar subjects in the same age group, given a total of 33 subjects minimum.

We analyzed our data with SPSS software for Windows, expressed as mean + or- standard deviation and frequency. Comparison of averages with ANOVA. The relationship between the variables by Pearson's correlation and the significance level was $p < 0.05$.

**Ethical considerations**

This study received approval No. 237 / CNE / SE / 2010 from the national ethics committee and research authorization from the management of the Yaoundé Central Hospital. Beforehand, each subject was informed about the procedure and the side effects. After their approval, during the study we insisted on respecting medical confidentiality, the results were communicated to them without any contribution of any kind whatsoever being required. The computerized data has been processed anonymously.

**RESULTS**

Sixty-one people agreed to participate in the study, given a response rate of 85.9%. Thirteen were excluded after a preliminary examination, for a total of 48 subjects.

We studied 48 subjects with an average age of 28 ± 6 years, the average BMI was 28 kg / m2, with 14 classified as normal weight, 16 as overweight and 18 obese. Blood pressure was higher in obese subjects with a statistically significant difference $p = 0.03$.

Obese subjects had a higher body fat percentage; with a statistically significant difference $p = 0.00$.

**Table I: Participant's characteristics**

| Characteristics | Obesity | Overweight | Normal weight | Total |
|---|---|---|---|---|
| **Age mean (±SD) (ans)** | 30 (±4) | 31 (±8) | 26 (±3) | 28 (±6) |
| **BMI mean (kg/m2)** | 18 (38%) | 16 (33%) | 14 (29%) | 28 |
| **Insulin Sensibility (%/min)** | 1.72 | 1,69 | 1,67 | 1.69 |
| **Waist Circumference (cm)** | 108 | 82 | 74 | |
| **Total fat at CT-Scan (cm)** | 698 | 331 | 192 | |
| **Visceral fat (cm)** | 102 | 61 | 41 | |
| **Subcutaneous fat (cm)** | 591 | 269 | 149 | |

Clinical abdominal adiposity estimated by waist circumference was higher in obese subjects. There was a statistically significant difference of p = 0.03. On CT scan, subcutaneous adiposity was greater than visceral adiposity. In our study population there was a statistically significant difference p = 0.00 in the different groups. A few cases of hepatic steatosis were found more in obese population than other: 9% of obese. The cholesterol level was higher in the obese population. There was a statistically significant difference for total cholesterol p = 0.045 and triglycerides p = 0.03 in contrast to LDL and HDL cholesterol with no statistically significant difference.

**Table II: Correlation between determinants of adiposity and insulin sensitivity**

| Abdominal FAT | Correlation with insulin sensitivity (KITT) | |
|---|---|---|
| | p | r |
| **BMI** | 0,062 | 0,271 |
| **Waist Circumference** | 0,278 | 0,056 |
| **Total fat at CT-Scan** | 0,032 | 0,310 |
| **Subcutaneous fat at CT-Scan** | 0,041 | 0,296 |
| **Visceral fat at CT-Scan** | 0,009 | 0,375 |

Regarding fasting blood sugar, it was higher in obese subjects. There was no statistically significant difference between the different groups p = 0.819.

Insulin sensitivity, via KITT, varied between 1.58% / min and 2.08% / min for an average of 1.69% / min; it was higher in obese subjects with an average of 1.72% / min ± 0.22. However, there was no significant difference.

KITT was not significantly correlated with BMI and waist circumference in our study population p=0,062 p=0,278, respectively.

The results showed a positive and statistically significant correlation between CT abdominal adiposity and insulin sensitivity p = 0.031.

Visceral CT abdominal adiposity being more correlated with insulin sensitivity p = 0.009 than subcutaneous p = 0.041.

The more components of the metabolic syndrome increased, the more insulin sensitivity decreased.

## DISCUSSION

### The method

Our study was made-up of 48 Cameroonian women. Sample size estimation was based on an expected difference in sensitivity to insulin of 20%, which gave a minimum size of 11 subjects per group, that is 33 subjects minimum. In an effort to increase statistical power, we extended the sample size to 48 subjects, comprising 14 women with normal weight, 16 overweight and 18 obese. All the women were of childbearing age and premenopausal for physiological reasons.

For the assessment of total adiposity, we used body mass index (BMI) and bio impedancemetry[5]. BMI had a major advantage over other techniques in its simplicity and reproducibility[5]. Although it is validated as a method of evaluating adiposity, the body mass index does not distinguish between fat mass and muscle mass and therefore may be a bias[6]. For example, in sportswomen with a large muscle mass. Also, the problem of threshold values which vary a lot according to the studies: we used the one defined by the WHO[7]. We also used impedancemetry which is certainly a rapid measurement that can be used clinically and validated, but less precise than the reference technique of hydrodensitometry. However, we did not use hydrodensitometry due to the difficulty of performing and the uncomfortable nature of the subjects who had to be fully submerged. The use of two-photon absorptiometry or DEXA was possible since the technique is validated to assess total adiposity but we do not have it[8].

### The results

The mean age of the subjects of 28 ± 6 years, and were mostly obese. The parity found in the majority of these women is thought to be associated with obesity[3]. The Stockholm Pregnancy and Weight Development study showed that the weight gained during pregnancy was a strong predictor of weight retention one year after childbirth. Without forgetting the constitution of adipocytes, one of the main periods of which is the first postnatal year. The rate of cardiovascular risk factors was higher in obese people, certainly due to the increase in adipose tissue correlated with the presence of cardiovascular risk factors[9].

Total adiposity: obese women had the highest percentage of body fat that could be justified by the accumulation of adipose tissue characteristic even of obesity (WHO Expert Committee on Physical Status: the Use and Interpretation of Anthropometry) [7].

Clinical abdominal adiposity: waist circumference was higher in obese subjects and significantly correlated with BMI; Indeed, the accumulation of adipose tissue is characteristic of obesity as well as its direct relationship with demonstrated subcutaneous abdominal adiposity[10].

Computed tomography abdominal adiposity: There was a good correlation between BMI, waist circumference and total abdominal computed tomography adiposity, and obese subjects had the largest abdominal subcutaneous adipose areas as demonstrated in some studies in females[11].

Concerning insulin sensitivity, it was reduced in our study population, especially in subjects with normal weight. Indeed, the fact that the BMI takes into account in addition to fat mass, muscle mass which is not a factor of insulin sensitivity, it is understandable that there is no significant difference between subjects all the more so as the BMI is more correlated with the subcutaneous abdominal adiposity than the visceral one. The sedentary lifestyle found in the majority of our subjects confirms the description by Ruderman and al of cases of subjects in normal weight but metabolically obese[12]. All of this confirms the limits of the relationship between total adiposity and insulin resistance. Although this relationship is established, it is not specific and there is another factor independent of the amount of fatty tissue but rather the quality of its distribution.

Regarding clinical abdominal adiposity and insulin sensitivity: No correlation between waist circumference and insulin sensitivity. Waist circumference was presented by Pouliot and al as a reliable measure of abdominal adiposity and as a strong predictor of metabolic syndrome for both sexes[11]. However, like our study, various others have questioned its clinical value as a reflection of abdominal adiposity, in particular that of Effoe et al in 2006[5]. In fact, waist circumference is influenced by subcutaneous abdominal fat and not visceral fat considering that the visceral has a major implication in insulin resistance via its proximity to the portal trunk[10,13].

Regarding CT scan abdominal adiposity and insulin sensitivity: our study demonstrated the existence of a significant correlation between insulin sensitivity and abdominal CT adiposity like other studies[5]. Indeed, Ziegler believes that each abdominal fat compartment has an influence on insulin sensitivity depending on different factors[14]. Visceral fat was significantly correlated with insulin sensitivity compared to subcutaneous fat. This confirms us in the portal hypothesis of insulinoresistance (hepatic) made of the release of fatty acids by visceral adipose tissue in the portal vein, which is one of the major mechanisms of metabolic abnormalities associated with insulinoresistance syndrome [4,15] the insulin tolerance test does not, however, make it possible to discriminate between overall insulin sensitivity and hepatic.

The more components of the metabolic syndrome increased, the more insulin sensitivity decreased. This confirms that insulin resistance would be the fundamental determinant of the metabolic syndrome as demonstrated by Bonora et al[16] without being the initial metabolic abnormality. We found out few cases of hepatic steatosis, the main hepatic manifestation of the metabolic syndrome, especially in the obese population (9% of obese).

## CONCLUSION

Our results show a discrepancy between clinical and CT-scan fat measurments. They confirm that BMI is not a reliable clinical measure of insulin sensitivity (Reaven, 2005); the waist circumference is more correlated with CT scan fat than BMI and CT scan visceral fat is the most reliable measure of insulin sentivity. Our study therefore demonstrates the complexity of the clinical determinants of insulin sensitivity in Cameroonian women of childbearing age and suggests for reduce the cardiometabolic risk to have new clinical determinants adapted to our population, and the accessibility of the CT abdominal scan which still posing a problem of affordability.

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