JIRESH-Biotech

Journal of Innovation and Research in Health Sciences & Biotechnology: Open Access

Volume 1, Issue 2, December 2015 http://jiresh-biotech.edmgr.com

Original Article

Frequency and Determinants of Visceral and Subcutaneous Obesity in a Student Environment at the University of Kinshasa, Democratic Republic of the Congo

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***J. innov. res. health sci. biotechnol.* 2015; 1(2): 56 – 62.** **doi: 10.18644/jiresh-biotech.0000010**

ABSTRACT

Background: Sub-Saharan Africa is facing a dramatic increase in the frequency of non-communicable diseases, among which are cardiovascular diseases and obesity. Since cardiovascular risk is continuous and often starts from childhood, it is appropriate to evaluate it in youth for better preventive strategies. The study sought to assess the frequency and determinants of visceral and subcutaneous adiposity among students at the University of Kinshasa, as well as consistency in terms of diagnosis between the bio-impedance measurements and clinical assessment. **Methods:** Cross sectional and analytical study designs using the bio-impedance measurement of visceral and subcutaneous adiposity. Multiple linear regressions in multivariate analysis were used to assess independent determinants. The statistical significance was set at $\rho < 0.05$. The degree of agreement between the measure of adiposity by bio-impedance and other means of clinical assessment was evaluated using the Kappa index. **Results:** The mean age and standard deviation (SD) of the students was 25 ± 3.5 years (20 to 33 years). Men were predominant, with a sex ratio of 3.6. Visceral and subcutaneous adiposity were found respectively, in 7.7% and 38.5% of students. Body mass index (BMI) and waist circumference (WC) emerged as independent determinants of visceral adiposity ($p=0.0001$ and 0.027 respectively), whereas BMI and the duration of physical activity were significant for subcutaneous adiposity ($p=0.0001$ and 0.005 respectively). This study found a significant agreement (kappa = 0.649, $p < 0.001$) between the measurement of visceral adiposity by bio-impedance and by clinical assessment (WC). **Conclusion:** A relatively high frequency of visceral and subcutaneous obesity was found, with BMI and WC as independent determinants of visceral adiposity whilst BMI and duration of physical activity were shown as independent determinants of subcutaneous adiposity. A strong correlation between the extent of adiposity by bio-impedance and by clinical assessment (WC) was also found.

Keywords: *Determinants, Adiposity, visceral and subcutaneus obesity, bio-impedance, waist circumference, cardiovascular risk factors*

RÉSUMÉ

Contexte : L'Afrique sub-Saharienne est confrontée à une hausse alarmante de la fréquence des maladies non transmissibles, parmi lesquelles se trouvent les maladies cardiovasculaires et l'obésité. Puisque le risque de développer une maladie cardiovasculaire est continu et débute souvent à l'enfance, il est pertinent de l'évaluer lors de l'enfance pour de meilleures stratégies préventives. Cette étude visait à évaluer la fréquence et les déterminants de l'adiposité viscérale et sous-cutanée parmi les étudiants de l'Université de Kinshasa de même que la cohérence quant au diagnostic entre les mesures de bioimpédance et l'évaluation clinique. **Méthodologie :** Une étude transversale et analytique examinant les mesures de bioimpédance de l'adiposité viscérale et sous-cutanée. Une analyse multivariée par régression linéaire multiple a été utilisée pour évaluer les déterminants indépendants. La signification statistique a été fixée à $p<0.05$. Le degré d'accord entre les mesures d'adiposité par bioimpédance et par d'autres moyens d'évaluations cliniques a été évalué selon l'indice Kappa. **Résultats :** L'âge moyen et l'écart type des étudiants étaient 25 ± 3,5 années (20 à 33 ans). Les hommes étaient en prédominance avec une proportion des sexes de 3.6. La fréquence de l'adiposité viscérale et sous-cutanée a été trouvée respectivement dans 7,7% et 38,5% des étudiants. L'indice de masse corporelle (IMC) et le tour de taille se sont révélés être des déterminants indépendants de l'adiposité viscérale ($p=0,0001$ et 0,027 respectivement), alors que l'IMC et la durée de l'activité physique étaient des facteurs considérables quant à l'adiposité sous-cutanée ($p=0,0001$ et 0,005 respectivement). Cette étude révèle une concordance significative entre la mesure de l'adiposité viscérale par bioimpédance et par évaluation clinique. **Conclusion :** Les résultats montrent une fréquence relativement haute d'obésité viscérale et sous-cutanée parmi les étudiants avec, d'une part, l'IMC et le tour de taille comme déterminants indépendants de l'adiposité viscérale et, d'autre part, l'IMC et la durée de l'activité physique comme déterminants indépendants de l'adiposité sous-cutanée. Une forte corrélation a également été observée entre l'étendue de l'adiposité par bioimpédance et par évaluation clinique.

Mots clés : *Déterminants, adiposité, obésité viscérale et sous-cutanée, bioimpédance, tour de taille, facteurs de risque cardiovasculaire.*

INTRODUCTION

The Obesity in children and young adults, has become a major public health problem worldwide and in sub-Saharan Africa (1, 2). In Kinshasa (DR Congo), Bukabau et al. found 5% obese among secondary school finalists aged 16 to 24 years (3). The World Health Organization (WHO) made the fight against obesity among young adults a priority, in order to prevent hypertension (HTN) and diabetes mellitus, as an effort to reduce cardiovascular morbidity and mortality (1, 4).

Until presently, evaluation studies of cardiovascular risk show that the accumulation of visceral adipose tissue plays a key role (5); however, its measurement is usually not performed routinely in medical practice. Its assessment is often done using surrogate measures such as waist circumference (WC), the wait-hip ratio (WHR) and body mass index (BMI). The sensitivity of these surrogate measures is low (6).

In order to validate the results found elsewhere with those from our environment, and also contribute to the fight against childhood obesity, this study aimed to determine the frequency and determinants of visceral and subcutaneous adiposity using bio-impedance, and also evaluate its consistency with other clinical parameters such as WC.

MATERIALS AND METHODS

This cross-sectional and analytical study was performed from 20 December 2011 to 10 February 2012. It targeted University of Kinshasa (UNIKIN) students living in student's residence.

Considering a frequency of 5% obesity in schools (3) and α error risk of 5%, an accuracy of 95% and a non-response rate of 10%, the sample size was estimated at 81 participants. Sampling was systematic. The sampling interval was determined by reference to the number of students in each residence, and number of studios in each residence. When the studio was inhabited by more than one student, researchers proceeded to a draw in order to retain only one student.

The parameters of interest were: age, sex, alcohol intake, cigarette smoking, blood pressure (BP), heart rate (HR), BMI, capillary blood glucose, the percentage (%) of visceral fat and that of the subcutaneous fat according to weight and height.

Alcohol intake was defined as consumption of more than 20 g of alcohol or 2 glasses per day for women and more than 30 g or 3 glasses for men (7). Blood pressure and HR were measured non-invasively using an OMRON sphygmomanometer; the values were considered as the average of 3 measurements. Hypertension was defined as BP ≥ 140/90 mmHg (8), pre-hypertension was defined by values of systolic and diastolic BP of 130-139 mmHg and 80-89 mmHg respectively. Tachycardia has been defined by a HR ≥ 90 beats per minute. Body mass index was calculated by dividing the weight by the height squared. Obesity and overweight was defined by values of BMI ≥ 30 kg/m² and between 26 and 29.9 kg/m² respectively (9). Capillary blood glucose (mg/dl) was measured casually with a one touch brand Ultraglucometer. Hyperglycemia was defined as blood glucose levels ≥ 140 mg/dl (10). General obesity was defined as WC values ≥ 80 and 94 cm for men and women respectively (11).

Body composition was calculated using a proprietary device KARADA SCAN OMRON –BF 511 (Special balanced body composition monitor for electrical impedance) whose principle is based on bio-impedance. The device sends an extremely weak current of 50 kHz and <500 MA into the human body, to determine the amount of fatty tissue taking into account the weight, size, age and sex. The conditions for measuring the bio-impedance were: a rest of at least 2 h without eating anything, the balance being placed on a hard level surface, the patient in an upright position. Excess visceral fat (visceral obesity) was defined by a percentage of visceral fat ≥ 10% of body weight (BW), and excess subcutaneous adiposity (subcutaneous obesity) by subcutaneous fat values ≥ 20% of PC for men and ≥ 33% for women (2).

Statistical Analysis:

SPSS Version 19 was used for data entry and statistical analysis. The results were expressed as mean ± SD or as median with extreme depending on whether the data distribution was Gaussian or not. Comparison of groups was performed using the chi-square test or Student's t as appropriate. Pearson correlation was used to investigate the relationship between visceral and subcutaneous adiposity and other variables of interest. Multiple linear regressions were used to identify determinants of visceral subcutaneous adiposity. A p value <0.05 was considered for statistical significance. The Kappa index was used to assess the level of agreement between the evaluation of visceral obesity estimated by bio-impedance and the WC (clinical parameters). All the participants signed informed consent.

RESULTS

General characteristics:

Seventy-eight students, including 78.2% men (n = 61), aged 20 to 33 years, participated in this study. Their general characteristics are presented in Table 1.

Table 1 General characteristics of the study population as a whole and according to gender

Variables	Whole group	Female	Male	ρ-value
	n=78	n=17	n=61	
Age (years)	25.6±3.5	23.2±2.8	26.3±3.4	0.001
Cigarette smoking (cigarettes/day)	1.9±0.2	2±0.0	1.9±0.3	0.284
Alcohol (glasses/day)	1.3±0.4	1.7±0.5	1.2±0.4	0.0001
Physical activity (min/day)	96.7±78.3	55.9±28.0	109.1±84.4	0.013
BMI (kg/m²)	22.0±2.8	22.3±2.8	21.9±2.8	0.586
WC (cm)	75.9±7.9	74.9±7.3	76.1±8.1	0.590
SBP (mmHg)	128.6±12.3	126.2±13.5	129.2±12.0	0.373
DBP (mmHg)	145±4.9	77.8±10.0	77.8±9.1	0.984
HR (beats/min)	74±11.1	79±11.1	72±10.7	0.036
Glycemia (mg/dl)	113±25.4	123±33.6	110±22.2	0.066

Abbreviations: SBP= systolic blood pressure, DBP= diastolic blood pressure, HR= Heart rate, BMI= body mass index, WC= waist circumference

Visceral and subcutaneous adiposity and obesity:

The distribution of visceral fat showed no significant difference between men and women (p =0.990), while that of subcutaneous fat showed a female predominance (p =1.001). The frequency of visceral and subcutaneous obesity was 7.7% and 38.5% respectively with a predominance of visceral obesity in men (p =0.001) as depicted in Table 2.

Table 2 Adiposity, visceral and subcutaneous obesity

Variables (%)	Whole group (n=78)	F (n=17)	M (n=61)	ρ-value
Visceral adiposity (mean)	4.0±0.7	4.0±2.4	4.0±2.8	0.990
Subcutaneous adiposity (mean)	39.7±5.7	39.7±5.7	25.6±3.8	0.001
Visceral obesity (n/%)	6/7.7	1/1.3	5/6.4	0.001
Subcutaneous obesity (n/%)	30/38.5	17/21.8	13/16.7	0.908

Correlation between subcutaneous/visceral adiposity and other cardiovascular risk factor (CVRF):

Factors correlated with visceral adiposity were: BMI (r = 0.894, p = 0.001), WC (r = 0.806, p = 0.001), SBP (r = 0.333, p = 0.003) and glucose levels (0.373, p = 0.001). Factors related to subcutaneous adiposity were BMI (r = 0.646, p = 0.001), WC (r = 0.534, p = 0.001), glucose (r = 0.389, p = 0.001) and the duration of the physical activity in minutes (r = 0.29, p = 0.013) (Table 3).

Table 3 Simple correlation between subcutaneous/visceral adiposity and other CVRF

Variables	Visceral adiposity	Subcutaneous adiposity
	r (p)	r (p)
Physical activity (min)	-0.125 (0.292)	-0.290 (0.013)
BMI (kg/m²)	0.894 (0.001)	0.646 (0.001)
WC (cm)	0.806 (0.001)	0.534 (0.001)
SBP (mmHg)	0.333 (0.003)	0.186 (0.103)
Glycemia (mg/dl)	0.373 (0.001)	0.389 (0.001)

abbreviations: BMI= Body mass index, WC= waist circumference, SBP= systolic blood pressure.

Determinants of visceral and subcutaneous adiposity:

After adjusting for visceral adiposity, successful factors were BMI and WC (Table 4). An increase in BMI by one unit (1 kg/m²) causes an increase in visceral adiposity by 0.72%; an increase in WC by a unit (1 cm) is associated with an increase in visceral adiposity by 0.20%. The observed model explains 81% variation in visceral adiposity. For subcutaneous adiposity, successful factors were: BMI and physical activity (Table 4). An increase in BMI by one unit (1kg/m²) causes an increase in subcutaneous adiposity by 0.63%; increase in physical activity causes a decrease in the subcutaneous adiposity by 0.25%. However, the model explains only 49% variation in subcutaneous adiposity.

Table 4 Independent determinants of visceral and subcutaneous obesity in multivariate analysis

Variables	B	p	CI	R^2
Visceral adiposity				
BMI	0.726	0.0001	(0.521 - 0.863)	0.81
WC	0.203	0.027	(0.008 - 0.0131)	
Subcutaneous adiposity				
BMI	0.634	0.0001	(1.593 - 2.774)	0.49
Duration of physical activity	-0.25	0.005	(-0.052 - 0.01)	

Concordance between the measuring of visceral obesity claimed in bio-impedance and that by clinical assessment (WC):

The correlation between the measurement of visceral obesity and the bio-impedance by clinical assessment (WC) showed a Kappa index of 0.649 (p< 0.001).

Cardiovascular risk factors (CVRF) associated with Obesity:

The frequency of other cardiovascular risk factors in the whole collective group was: 26.9% (n = 21) for hypertension; 17.9% (n = 14) for pre-hypertension; 5.1% (n = 4) for tachycardia; 11.5% (n = 9) for casual hyperglycemia; 12.8% (n = 10) for overweight; 9% (n = 7) for central obesity; 6.4% (n = 5) for physical inactivity; 5.1% (n = 4) for cigarette smoking and 73.1% (n = 57) for alcohol intake.

DISCUSSION

The results obtained from this study show that visceral and subcutaneous obesity measured by bio-impedance, were common among students of University of Kinshasa (DR Congo); BMI and WC were the main determinants of visceral adiposity, whereas BMI and duration of physical activity were the determinants of subcutaneous adiposity. The level of agreement between the measurement of obesity by bio-impedance and WC was significantly elevated.

Visceral and subcutaneous obesity:

The significant increase in the prevalence of obesity in the world has prompted WHO to brand it as the millennium disease. Obesity is a pandemic, and represents one of the most dreadful public health problems. For a long time, fat was considered a passive entity without any physiological function, playing the only role of thermal insulation and storage of Triglyceral (12). In the 1950, the so-called clinical android obesity (abdominal) was described as promoting type 2 diabetes and atherosclerosis. It was only from the 1980 that the concept of metabolic syndrome was proposed under the following names: Syndrome X, multi-metabolic syndrome, insulin resistance syndrome. Thus the relationship between metabolic dysfunction and abdominal accumulation was demonstrated (12).

Advances in medical imaging have made it possible to distinguish between different kinds of adipose tissue and determine their respective locations. This is the case of the electrical scale used in this study, which allows bio-impedance measuring of visceral and subcutaneous fat (13-16). Indeed, the severity of obesity is more strongly related to the type of fat distribution in the body than its total amount (12). Adipose tissue represents a considerable body organ composed of several types of cells having different capacities; hypertrophy, hyperplasia and differentiation.

The frequency of visceral and subcutaneous obesity found in this study confirms the literature data (17). This relatively high frequency of visceral and subcutaneous obesity in student environment constitutes a negative image in terms of public health, since adiposity (visceral and subcutaneous) is a CVRF. This can be justified by a hight-fat diet that characterizes university restaurants in Kinshasa.Till date, several studies published; have evaluated the clinical estimate of obesity (18).

The interest in the study of obesity and other cardiovascular risk factors increases in developing countries. A marked increase in the frequency of obesity had already been reported since 1990 (18). In the Middle East, its frequency is 38 to 44% (19-21). It is 21% in USA and 23% in Canada, regardless of gender (22, 23).

Determinants of visceral and subcutaneous adiposity:

It is well established that high BMI is a CVRF (24). Although BMI is often used in the assessment of obesity, it does not provide information on the distribution of body fat. According to several studies (25-28), measures of abdominal adiposity such as WC, are most closely associated with cardiovascular morbidity and mortality than BMI. Several health organizations recommend using the surrogate measure of adiposity, mainly WC within BMI categories for classifying risks of obesity-related health problems (24, 29-31).

The data collected within the student population shows the existence of an association between certain anthropometric (BMI, WC), hemodynamic (SBP, DBP), biochemical (Glycemia) data, physical activity on the one hand and adiposity (visceral and subcutaneous) on the other hand. BMI and WC were independently and positively associated with visceral adiposity in this study, whereas BMI (positive influence) and physical inactivity (negative influence) were associated with subcutaneous adiposity. Since the 1990s, many studies have shown the important value of WC as compared to BMI in the prediction of cardiovascular risk (32). But these two indicators are useful and complementary. Their use depends on the context of the study (surveillance, descriptive or analytical study). Several studies have shown that the WC was more closely correlated with visceral adiposity than subcutaneous (33).

Concordance between measure of obesity by bio-impedance and WC:

The correlation between the measurement of visceral fat by bio-impedance and that of clinical estimate (WC) was also satisfactory in the present study. Anthropometric indicators of Validation studies have established the fact that the WC was better correlated with visceral fat ($r = 0.80$), and with body fat by CT scan (34) . It was also found in this study, that there was an independent and positive association between WC and visceral adiposity when bio-impedance was used for measurement. However, in practice, the measure of WC information is the only useful way of determining abdominal adiposity. In all cases, examination of body composition by an experienced clinician, allows the inspection of suspected profile of body composition: abdominal adiposity is often associated with metabolic syndrome (34).

The use of bio-impedance for measuring obesity has all the advantages of a measuring tool on a large scale (easy to use, inexpensive, painless), however, it also has a drawback, which is inaccuracy of the measurement, because of the indirect nature of estimated body fat

based on weight and body water contained in lean mass (35).

CONCLUSION

A high frequency of Visceral and subcutaneous obesity was found among students in Kinshasa (UNIKIN / DR Congo). BMI and WC were independent determinants of visceral adiposity while BMI and physical activity were determinants of subcutaneous adiposity. There was a strong agreement between the measurement of visceral fat by bio-impedance and that of clinical assessment (WC).

Competing Interest:

Authors declare that they have no competing interest.

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