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An Exploratory Study of Respiratory Profile in 11 - 18 Years Old Obese Congolese Children

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Abstract

No studies on the spirometric profile of obese adolescents in sub-Saharan Africa exist. The objectives of the study are: 1) to determine and compare the ventilatory values, the forced expiratory flow rates and the pulmonary reports with the reference values; 2) determine the percentages of subjects with abnormal ventilatory volumes, or an obstructive ventilatory deficit, or a static pulmonary distension; 3) examine the impact of anthropometric parameters and body composition on FEV1 and FVC in school children aged 11 - 18 years. A total of 1,138 obese adolescents (412 boys and 726 girls), belonging to 132 colleges and high schools in Brazzaville, participated in the study. They were selected by a 2-degree cluster survey on the obesity criterion. Spirometric values were measured according to the recommendations of scientific societies, as well as the definitions of respiratory anomalies. The results showed that all forced respiratory rates were reduced, the lung volumes (FVC, VC, IC, TPC) were increased compared to normal values, as well as the FEV1 / CVF and CI / CPT ratios. In addition,83.7% of cases (n = 952) of obstructive ventilatory deficit were found. Among the cases of moderate ventilatory deficit (n = 186), 29.5% of cases (n = 54) of mixed ventilatory deficit were found. In conclusion, obesity affect respiratory function. This study provides the health authorities with valid authorities to fight this scourge which increasingly affect school adolescents.

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Keywords

Spirometry, Obesity, Deficit, School environment, Adolescence

Introduction

The last thirty years of the 20th century and the first decades of the 21st century are marked by profound lifestyle changes that have contributed to the establishment of a veritable pandemic of adult obesity worldwide, which has become a major public health problem with a prevalence higher than 25% (WHO, 2018; Brantley *et al.*, 2002). Children and adolescents are not spared from this pandemic (Wang and Lobstein, 2006). In Europ, the number of obese children (BMI ≥ 90th percentile) has more than doubled since the 1980s (Sassi *et al.*, 2009 ; Zimmerman *et al.*, 2000). In Lebanon, 25 to 35% of children in 2017 are overweight and 5 to 15% are obese (Nasreddine *et al.*, 2012). In the United States, the prevalence of obesity in adolescents is estimated to 42.3% according to data from the review of Ogden *et al.*, (2010). Africa does not remain on the sidelines of this expansion of obesity (Bayauli *et al.*, 2018; WHO, 2017). In Congo-Brazzaville, the study of Mabiala Babela *et al.*, (2004) reveals a prevalence of obesity of 7.1% in 2003 among 12,416 children and adolescents in school (aged 7-16 years) compared to 1.9% in 2003 among 12,566 students of the same age group. Ten years later, a study carried out by the same team, carried out on 1,243 schoolchildren (age between 11-16 years) reports a prevalence of 7.1%. Even if the mechanisms behind fat storage remain poorly understood, obesity results from the interaction of environmental factors (overeating and / or reduced physical activity) and hereditary factors as shown by numerous epidemiological studies carried out in several populations (Dumith *et al.*, 2011; Swinburn *et al.*, 2011).

Obesity is a pathology which leads, directly or through associated pathologies ; it is characterized by significant early excess mortality. Among the main complications of obesity, pulmonary complications occupy prominent rank. The negative impact of obesity on pulmonary function (PF) has been reported by many authors. Classically, obese children have a decrease in pulmonary compliance, residual functional capacity and respiratory reserve volume, a preserved total pulmonary capacity as well as vital capacity (Franssen *et al.*, 2008; Mota et*al.*, 2006; Zerah *et al.*, 1993;). However, the pulmonary volumes and the maximum expiratory flow vary with age, and consequently with the morphology of the individual. In fact, puberty, a very important stage in the life of a child, is characterized by hormonal, sexual, structural and intellectual changes (Tanner, 1962). These variations, found from one child to another, are also explained by the differences between the populations (Harik-Khan *et al.*, 2006). Since puberty is characterized by morphometric changes that affect lung volumes, it is justified to analyze the consequences of these changes on the spirometric variables (Degrood *et al.*, 1989). In addition, the literature review highlights that the lung is very sensitive to environmental and geographic factors (air pollutants, altitude, …), which are responsible for a significant change in lung volumes and expired maximum flows (Dockery *et al.*, 1982). It is in this context that several studies have been undertaken around the world on the spirometric profile of children and adolescents (Zapletal *et al.*, 1969; Ip *et al.*, 2000; Kaditis *et al.*, 2008; Tsai *et al.*, 2018; Veeranna et Rao, 2004). In Africa, numerous studies are conducted in Maghreb (Bougrida *et al.*, 2012; Trabelsi *et al.*, 2004; Shamssain *et al.*, 1988), and West Africa (Glew *et al.*, 2004). In Central Africa, two studies had been identified : Pefura-Yone (2015) in Cameroon and Dedoyard (1972) in Democratic Republic of Congo. In Congo-Brazzaville, three studies are reported in literature. The first study focused on Congolese children and adolescents aged 8-20 years (Packa-Tchissambou *et al.*, 2009). The spirometric variables were forced vital capacity (FVC), maximum expiratory volume second (FEV1) and peak expiratory flow (PEF). The second study is that of Bazaba Kayilou et *al*(2016) which concerned 11,994 children and adolescents attending school in rural and urban areas; the same spirometric variables were noted. The last study is that of Massamba et *al.*, (2018), which examined the impact of physical exercise program on the respiratory profile (FVC, FEV1, FEV1 / FVC, V_{max50}, DME_{25-75}, DME_{25-75} / FVC, RV, V_E, FE_{CO2}, Ti, Vi / Ti) in 34 obese adolescents aged 12-15 years.

However, these studies have limited methodologies: measurement of only three spirometric parameters (FVC, FEV1 and PEF) and non-application of recent spirometric recommendations and definitions (ATS, 1991 ; ERS, 1993) for the studies of Packa Tchissambou et *al*,Bazaba Kayilou et *al.*,; small sample size for the study by Massamba *et al.*, The absence of epidemiological data on the spirometric profile of obese adolescents justifies the present investigation. The objectives of our study are to: (1) determine and compare the ventilatory values, the forced expiratory flow and the pulmonary ratios with the reference values; (2) determine the percentages of subjects with abnormal ventilatory volumes, or obstructive ventilatory deficit, or static pulmonary distension; (3) examine the impact of anthropometric parameters and body composition (height, bust length, thoracic perimeter, fat mass,lean body mass) on FEV1 and FVC in schoolchildren aged 11-18 years old.

Materials and Methods

Context of the study and subjects

This cross-sectional study, over 6 months (from August 2019 to January 2020), was conducted in the capital city of Brazzaville. The population of study was included pupils from middle and high schools in Brazzaville. The maximum number of middle and high schools has been contacted in writing after the consent of the administrative authorities of secondary establishments in the city of Brazzaville. The sample size was determined using the predictive equation (Huguier and Boëlle, 2013):

$n = (Z^2.p.q) / \Delta^2$, where n is the number of subjects required, Z is the 95% confidence level ($Z = 1.96$) and p is the estimate of obesity among Congolese adolescents attending school. According to the Congolese literature (Mabiala Babela *et al.*, 2004), 9.3% of schoolchildren are obese. The value $q = 1-p$ is then equal to 0.91; Δ the accuracy is estimated at 5%. According to this formula, the number of obese adolescents in school is at least 130. The sampling was carried out after determining the schools under the three sectoral education inspectorates of the city of Brazzaville. Of the 126 colleges and 31 highschools (private and public) in this city, 2 random draws with a fraction of 1/5 were carried out in order to stop the number of establishments by sectoral inspection. In addition, the inclusion criteria were: consent of the school heads to participate in the study; more than 200 students per establishment; state approval of the establishment. Fifty-two colleges (29 private and 23 public) were selected at the end of this process. Within each establishment, two classes were selected by studylevel according to a random draw. A total of 1,725 students [673 (43%) boys and 1,052 (57%) girls] were involved in the study. The pupils were excluded: smokers, carriers of respiratory symptoms and pathologies (deformation of the chest or spine, heart disease); resident in Brazzaville for less than a year. Parental and child consent to participate in the study was required orally or in writing.

The study received the approval of the National Committee for Ethics of Research in Health Sciences of the Congolese Ministry of Scientific and Technical Research, while obeying the recommendations of Helsinki.

Measurements

Height was measured in all children using stadiometer (Seca Ltd. Hamburg, Germany; nearest to 0.1 cm), body mass using a digital calibrated scale (Omron Health Care, to the nearest 0.1 kg) while the participants were light clothing, with no shoes. Body mass index (BMI) was calculated using the formula: Weight (kg) / $[\text{Height (cm)}]^2$. The BMI values were interpreted in relation to the Standard Deviation Standard (SDS) values of the LMS method [L: coefficient relating to the curvature of the BMI according to the Box-Cox transformation (data normality); M: median; S: variation coefficient] recommended by Cole *et al.*, (2000). Trunk length (LT) and thoraxperimeter were measured using a rigid measuring tape and recorded to the nearest 0.5 cm, from anatomical landmarks. The lean or muscular mass (LBM) was calculated using formula:

$$\text{LBM (kg)} = P - (P \times PCTG / 100)$$

where PCTG is the percent of fat mass (FM) determined using skinfold measurements. For adolescents aged 11-14 years, the skinfolds are tricipital and sub-scapular folds according to the predictive equations of Slaughter *et al.*, (1988). For adolescents aged 15-18 years, two other folds are added: the bicipital and supra iliac folds. Skinfolds to determine the percentage of fat mass were measured using a Harpenden adipometer (constant pressure : 10 g / mm^2), according to the recommendations of Lohmann *et al.*, (1986). Fat mass (FM, in kg) was calculated using the predictive equation of Heymsfield *et al.*, (1999): $FM = 4.95 \times BV - 4.50 \times P$, where BV (body volume, in liters) is the product body area (BA) x height(T) of subject. Body area BA was calculated using the formula of DuBois and DuBois (1916): $BA\ (cm^2) = P^{0.425} \times T^{0.715} \times 71.84$.

Vital capacity (VC), forced vital capacity (FVC), inspiratory capacity (TC), maximum expiratory volume second (FEV1), total lung capacity (TLC) and peak expiratory flow (PEF) were measured using a portable spirometer (KoKo Spirometry, aSpire Health Inc) after education of the subject. After obtaining 4 to 6 successive stable end-of-expiration volumes, the subject was asked to breathe to full lung capacity and then breathe normally. The FEV1/VC, FEV1 / FVC, TC/TLC ratios were calculated. The measurements were repeated to obtain a maximum variability of 5% on three consecutive measurements, and the largest value was that recorded.

Operational definitions

As recommended by Cole *et al.*, (2000), adolescents were defined as obese if they had a BMI SDS greater than 2, SD (or a BMI greater than the 97th percentile in the BMI curves in accordance with the recommendations of the European Childhood Obesity Group). When the BMI SDS value was between 2-3 SD, obesity was light; it was moderate if the SDS value was between 3-4 SD, severe if SDS score greater than 4 SD. The definitions used for the existence of ventilatory volume and forced expiratory flow are based on the identification of a lower limit of normal for each spirometric parameter studied. For this reason, the most methods of interpretation used in current medical practice have been applied (ERS, 1993; ATS, 1991).

The first method is based on “fixed threshold values” outside which the ventilatory variable (VV) will be considered as abnormal (ERS, 1993; ATS, 1991). For FEV1 and lung volume, VV is considered reduced when it is less than 80% of its reference value, normal between 80-120%, and increased when it is greater than or equal to 120%. For maximum expiratory flow and because of their great variability, VV is considered to be reduced when it is less than 50% of its reference value, normal between 50-120%, and increased when it is greater than or equal to 120%. For the FEV1 / FVC ratio, the threshold is set at 0.70.

The second method is based on the determination of the 95% confidence interval, and therefore on the application of the lower and upper limits of the normal (Pellegrino, 2006).

In our study, the international classification of the degree of severity of obstructive ventilatory deficit (OVD) based on FEV1 expressed as a percent of its reference value, was used: mild when FEV1 $\geq$ 70%; moderate, 60% $\leq$ FEV1 <59%; fairly severe, 50% $\leq$ FEV1 <59%, severe, 35% $\leq$ FEV1 <49%, and very severe, FEV1 <35%. Restrictive ventilatory deficit (RVD) is defined byTPC <N (Pellegrino *et al.*, 2006). The international classification of degree of severity of the RVD, based on the TLC expressed as a percent of its reference value, was used (ATS, 1991): light if 70% $\leq$ TLC$\leq$ N; moderate, if 60% $\leq$TPC <70%; engraved, if TLC<60%. Mixed ventilatory deficit (MVD) is defined by the combination of TLC<N and FEV1/FVC <N (Pellegrino *et al.*, 2006). Nonspecific ventilatory deficit is defined by a decrease (<N) in FVC and / or FEV1, with a normal FEV1 / VC ratio and TLC.

Variables

They included anthropometric and spirometric variablesanthropometric variables boiled down to height, bust length, chest perimeter, weight,BMI,body fat mass,lean body mass. The spirometric variables were divided into: (1) forced expiratory flow (FEV1, DEP); (2) lung volumes (FVC, VC, TC, TPC); (3) ratios (FEV1 / FVC, FEV1 / VC, TC / TCTC). All of these variables were studied by age and sex.

Statistical analysis

Data entry was carried out with Epi-info data software, version 3.0. The database was cleaned up on an Excel page (GLI-2012 software) and analyzed on SPSS software, version 23.0. Analysis of the normal distribution of the spirometric variables was carried out using the Kolmogorov-Smirnov test. In case of normality and equality of variances, data were expressed as means ± SD. The variables, categorical and quantitative, were presented in the form of tables and graphs. Student t test was used to compare two means. For the comparison of 4 means, one-way analysis of variance was used. In case of statistical significance, the Bonferroni post hoc test was applied to determine where the difference was. The Sokal S test was used for comparing 4 percentages (Sokal and Rolhf, 2005).Furthermore, in order to establish the predictive equations of VV as a function of anthropometric variables (BL, TP, FM, LBM), PLS (Partial Least Square Regression) statistical regression was used by partial triadic analysis (Hanafi and Quannari, 2006; Kissita *et al.*, 2004). Subsequently, regression curves were plotted: FEV1 = f (LMB), FVV1 = F (LBM), FEV1 = F (LBM), FVC = F (fat mass). For all tests, $p < 0.05$ was the threshold for statistical significance.

Results and Discussions

Out of 1,725 examined, 1,138 (66%) adolescents [412 boys (36.7%) and 726 girls (63.3%)] were included in the study on the basis of the following exclusion criteria: absence of health books for medical follow-up for (n = 413); imperfect completion of requested respiratory maneuvers (n = 174). The subjects were divided by civil age class [Ai, Ai + 1] (i varying from 11 to 17), or 4 one-year age classes centered on the average for the year (Figure 1): 11 - 12 years old, 54 subjects (4.7%); 13-14 years old, 127 subjects (11.2%); 15-16 years, 415 subjects (36.5%); 17-18 years, 542 subjects (47.6%).

The mean age was 14.7 ± 2.4 years (15.1 ± 2.6 years for boys and 14.3 ± 2.2 years for girls. The size distribution revealed that 809 subjects (71.1%) had mild obesity, 329 (28.9%) moderate obesity. Table 1 reports the distribution of subjects as function as degree of obesity and sex.

The anthropometric characteristics and body composition of subjects are reported in Table 2.

Statistical differences were found, in the bust length and the thoracic perimeter between the different age groups: the highest value being found in 13-14 year age groups forgirls (+10.9% for height, +10% cm for BL and + 23.3% for PT) and in 15-16 years for boys (+7.7% for BL). The other anthropometric variables of the subjects in the both sexes showed a fairly regular evolution with age, with the exception of FM; this decreased rate during the 11-12 and 13-14 year transition was -11.7% for boys ; in contrast, increased rate was found, +15.8% for girls. However,an increase was found after 15-16 years.

It can be seen from this table that all forced expiratory flow rates were reduced. Examination of FEV1 values revealed that 83.7% of subjects (n = 952) had mild DVO, and the remaining 186 had moderate DVO. In addition, among the 186 subjects with moderate DVO 54 of them (29.5%) had a mixed ventilatory deficit.

Table 4 reports the correlation coefficients between FEV1 and age on the one hand, anthropometric variables on the other hand according to the PLS regression.

The r-value examination shows that the determinants of FEV1 in boys were age, BMI, LB, PT and body fat; however age, bust length, and body fat had a negative impact on FEV1. For girls, the determinants were age, bust length, body mass index and body fat. While age, bust length and body fat also had a negative effect on FEV1. Figures 2 and 3 illustrate the regression lines of FEV1 and FVC as a function of lean mass.

Examination of the graphs shows an increase in the FEV1 and FVC values in relation to the lean mass rates. The two lines, VEMS = f (lean mass) and CVF = f (lean mass), are almost parallel.

The evolution of FEV1 and FVC as a function of fat mass (Figures 4 and 5), revealed a decrease of FEV1 was FVC was values and in FVC when fat mass increases.

The application of the PLS regression model show that it possible to establish two predictive FEV1 equations according to anthropometric variables, specific to each sex in the population of obese adolescents studied.

$FEV1 = -0.023\ Age + 0.0231IMC - 0.030LB + 0.031PT - 0.009MG - 1.453$, for boys

$FEV1 = -0.013\ Age - 0.08LB + 0.03PT + 0.018MG - 1.458$, for girls.

The aim of this survey was to establish spirometric references for the obese school population of Brazzaville, aged 11 to 18 years. The main observations revealed: 1) a reduction in forced expiratory flow (FEV1, DEP) and an increase in lung volumes (FVC, VC, IC, TPC) in all subjects; 2) superiority of spirometric values in boys compared to girls; 3) a negative influence of fat mass on FEV1 and FVC. Despite of increasing number of stadies on pulmonary function and body composition, there are still unanswered questions, such a the role of fat-freemass (lean mass more bone mineral content-FFM), which appears to be beneficial to PF due its correlation with respiratory muscle length (Parkow *et al.*, 1998 ; Chlif *et al.*, 2005).Our data related to the superiority of join spirometric values of non-obese adolescents of the same age group in our study join the observations of numerous reports from surveys carried out on Caucasian populations (Ip *et al.*, 2000; Kaditis *et al.*, 2008; Tsai *et al.*, 2018; Veeranna *et al.*, 2004), and even in Africa (Bougrida *et al.*, 2012; Trabelsi *et al.*, 2004; Glew *et al.*, 2004). The low values of FEV1, FVC, VC, IC, and CPT indicate lung abnormalities, as reported by our data. We found 87% of cases of mild DVO and 16.3% of moderate DVO. In addition, a rate of 29.5% of mixed ventilatory deficit was found. These anomalies are undoubtedly linked to the mechanical limitation of thoracic expansion (Park *et al.*, 2012). Indeed, the accumulation of fat mass in obese adolescent as shown in Table 2, could interfere with the movement of the chest wall and the descent of diaphragm. This may reflect intrinsic changes in the lung (Harik-Khan *et al.*, 2001). This reduction in values can also be explained by the fact that visceral adipose tissue influences the circulating concentrations of cytokines, such as interleukin-6 and TNF-α. Thus, a drop in the level of adiponectin increases the levels of systemic inflammation, which in turn adversely affects lung function through the reduction in the caliber of the airways.

Table.1 Distribution of subjects according to the degree of obesity and sex

	Light obesity	Moderate obesity	Total
Boys [n(%)]	268 (65)	144 (35)	412 (37.0)
Girls [n(%)]	541 (74.6)	185 (25.4)	726 (63.0)
Total	809	329	1138

Table.2 Anthropometric characteristics of subjects by sex and age group

	11 – 12 years	13 – 14 years	15 – 16 years	17 – 18 years
Height (cm)				
Boys	136.6 ± 6.5	151.5 ± 13.1	162.5 ±5.8	165.0 ± 10.3
Girls	138.9 ± 5.0	149.2 ± 6.0	159.5 ± 4.17	161.2 ± 8.5
BL (cm)				
Boys	52,2±2.2	52.4±2.2	57.5±3.1	65.3±2.5
Girls	47.4±3.1	52.6±2.8	55.7±2.3	61.8±3.4
TP (cm)				
Boys	74,4±3.2	76.7±2.9	79.5±3.4	83.1±2.6
Girls	71.6±2.7	88.3±3.1	90.8±3.3	93.8±2.8
Weight (kg)				
Boys	41.7 ± 6.5	53.2 ± 9.4	60.8 ± 6.0	67.6 ± 6.7
Girls	41.7 ± 3.6	58.4 ± 8.3	61.7 ± 5.2	69.4 ± 4.8
% FM				
Boys	17.1 ± 1.4	15.3 ± 3.2	17.3 ± 1.6	18.1 ± 2.3
Girls	18.3 ± 1.6	21.2 ± 3.1	23.2 ± 3.1	25.3 ± 1.6
LBM (kg)				
Boys	27.1 ± 0.5	35.5 ± 2.8	44.1 ± 3.9	48.6 ± 3.2
Girls	30.0 ± 3.3	38.2 ± 3.1	39.8 ± 3.2	40.9 ± 2.3

Abbreviations: LB, bust length; PT, thoracic perimeter; MG, fat mass; LBM, muscle mass.

Table.3 Comparison of the ventilatory variables measured in boys with the reference values

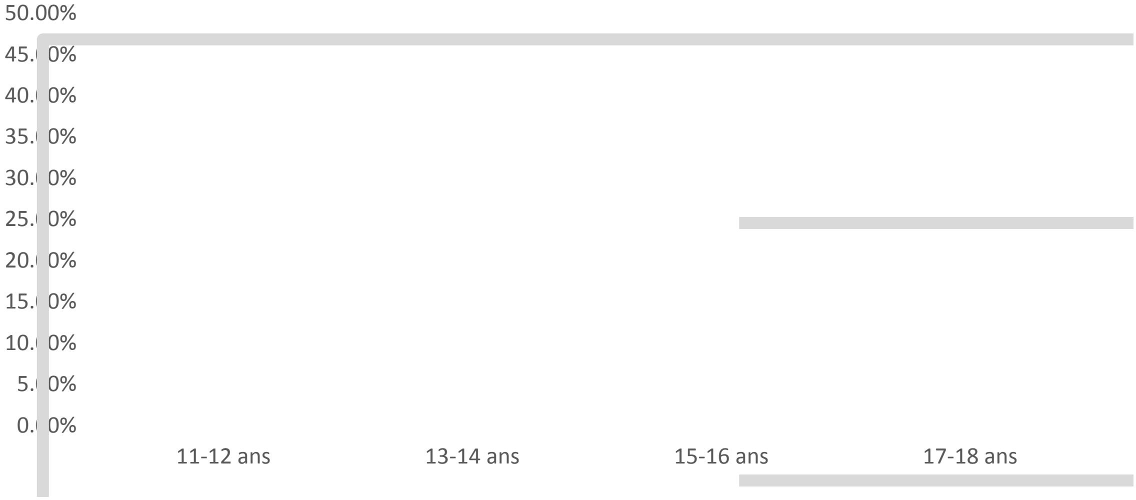
VV	Measured value	Measured value in% of the reference value	p
Expiratory flows			
FEV1 (l)	1.84 ± 0,45	94 ± 10	0.025
PEF (l / s)	2.38±0,21	91 ± 13	0.013
Pulmonary volumes			
FVC (l)	1.16 ± 0.41	97 ± 11	0.092
VC (l)	2.45 ± 0.17	90 ± 14	0.034
TC (e)	2.23 ± 0.62	96 ± 14	0.043
TLC (l)	6.8 ± 1.3	98 ± 12	0.092
Ratio			
FEV1/FVC	1.58 ± 0.25	98 ± 10	0.102
FEV1/VC	0.75 ± 0.23	97 ± 12	0.027
IC/TLC	0.32 ± 0.07	96 ± 15	0.041

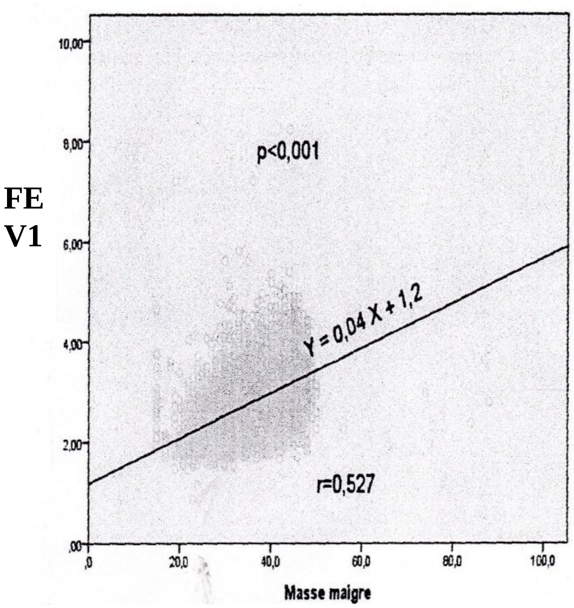
Abbreviations: VV, ventilatory variable; FEV1, second maximum expiratory volume; DEP, peak expiratory flow; FVC, forced vital capacity; VC, vital capacity; IC, inspiratory capacity; TLC, total lung capacity

Table.4 Correlation coefficient r of the FEV1 model according to age, sex and anthropometric variables

Variable	Boys		Girls	
	r	**p**	**r**	**P**
Age	-.023		-.013	
BL	+.54		+.58	
TP	0.31		0.44	
BMI	.023		0.30	
LBM	.03		0.48	
FM	-.59		-.52	

Figure.1 Distribution of the sample by 1 year age group





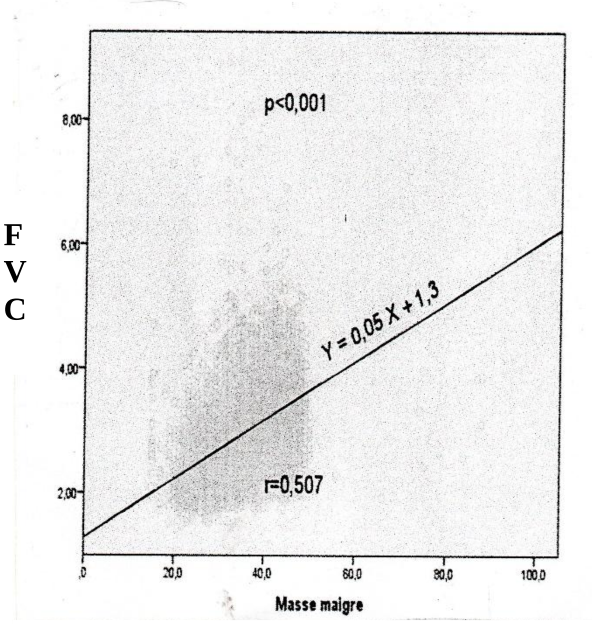


Figure 2: FEV1-Lean Mass correlation

Figure 3: FVC-Lean Mass correlation

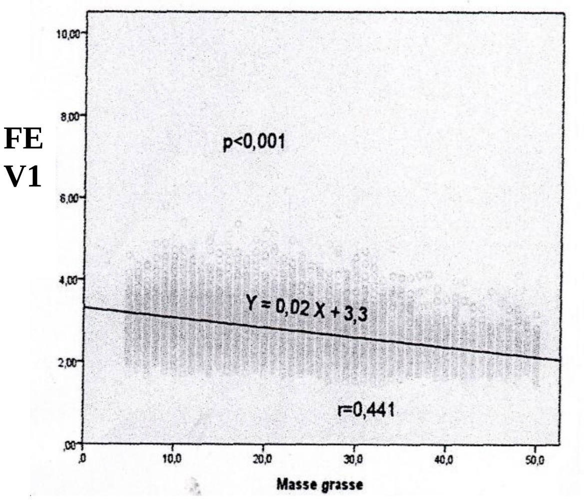


Figure 4: FEV1-Fat Mass correlation

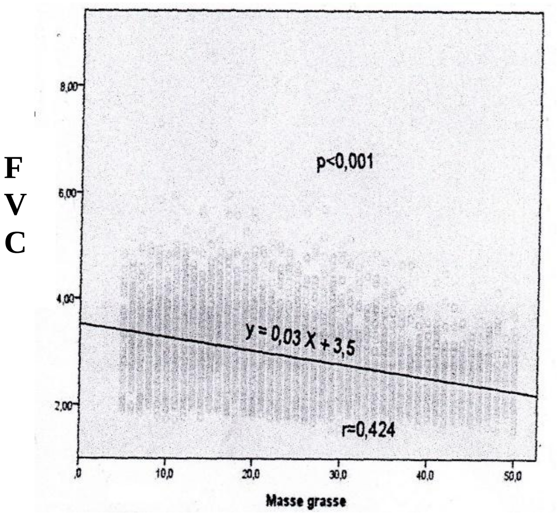


Figure 5 : FVC-Fat Mass correlation

The existence of mixed ventilatory deficit is linked to the absence of significant or massive obesity. Indeed, it is known that respiratory impairment only appears in the event of massive obesity without any proven pulmonary pathology (Dote and Orvoen-Frija, 2002). In addition, the absence of distal DVO in our subjects suggests that obesity does not impair respiratory function. This can probably be explained by the fact that obesity in subjects of this age group has no repercussions on the deep airways. However, nowadays the exact cause of respiratory limitation in obese subjects as observed in our study remains unknown. However, one possible mechanism could be the reshaping of the airways by pro-inflammatory adipokines and / or by the continuous opening and closing of small airways throughout the respiratory cycle (Park *et al.*, 2012).

Our findings show also that FM was inversely associated with FEV1, particularly in boys. Other studies with obese adolescents aged also found an associated of FM on PEF1 (Young Sik *et al.*, 2011, Castro-Pinero *et al.*, 2011). However, our results are attributed to the hypothesis that accumulation of FMare contrary to the hypothesis that accumulation of FM in the uper body is more harmful to PF than in the lower body (Collins *et al.*, 1995). Regarding the impact of the bust length on the FEV1 (Table 4), it appears from the literature that the BL does not allow to discriminate the visceral and subcutaneous sector of adipose tissue in the young obese, although showing a significant correlation with body fat and undoubtedly the abdominal perimeter(Piper and Grunstein, 2010 ; King *et al.*, 2005). The distribution of fat mass in visceral and subcutaneous areas but also between upper and lower parts has a different influence on respiratory volumes. The fat of the lower parts affects more than that of the lower areas, the decline in respiratory function as reported in other studies (Littleton, 2012; Ochs-Balcom *et al.*, 2006).

Our PLS regression results have shown a link between the degree of limitation of FEV1, FVC and fat mass. These observations are in agreement with the data from Babb et *al.*, (2008), authors who have shown a negative influence of fat mass on these two spirometric variables, with as a consequence the increase in the FEV1 / CVF ratio as noted in this work.

However, the interpretation of our results must take into account certain limits. The first is due to the very type of study and its cross-cutting nature which only allows for a time snapshot. The realization of a longitudinal and dynamic survey would have been better suited to the search for reference values. The second limit relates to the average expression of data, most likely influenced by the non-matching of the groups present. The preponderance of girls (63.3%) may have introduced confounding factors. Third, in our study only the association between FEV1 and body composition was analyzed. It would be appropriate and relevant to include more lung function variables and anthropometric measures to test the hypothesis cited above. Fourth, information on the morbid history of our subjects was based only on the statements of parents (or children) and the collection of health books (perhaps incomplete) of children. These limits mentioned do not, however, completely affect the power of our observations. This study is in any case the first of its kind in the Congolese environment and in Central Africa. The usual confounding factors in the interpretation of the results were discussed, in particular: sex, age and size, even if the altitude of the survey sites was not taken into account. The tests also respected a certain regularity as for the moment of their realization and, the best of the three recorded values was that retained according to the recommendations of the experts.

Ii is concluded in our results, while controlling for a few limitations, show once again that obesity affects respiratory function in adolescents. There is a decrease in forced expiratory flow rates and an increase in lung volumes. These variations reveal the presence of a ventilatory deficit in 87.3% of adolescents and a mixed ventilatory deficit in 29.5% of them. This study thus provides the Congo's health authorities with valid arguments to combat childhood and juvenile obesity.

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Auhor's contributions

Conceived and designed current analysis : MJM, MJGA, MSI, MMFQS. Performed statistical analyses : MA. Drafted the manuscript : MJM, MJGA, MBC. Supervised reserch and data collection : MBJR, MJM, MA, KNJM. Provided critical input and revised the manuscript for important intellectual content : All. Approved the final manuscript : All. Take responsability for the integrity of the data and the accuracy of the data : All

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