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Nutritional status and body fat distribution in children and adolescentes with Cystic Fibrosis

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Abstract *Objective: assessing the nutritional status and body fat distribution in children and adolescents with cystic fibrosis. Method: Fifty-six (56) 8-18 year old patients were assessed for fat distribution by dual energy X-ray absorptiometry, for nutritional status by height/age, and for body mass index to age and dietary intake by 24-hour dietary recall. Results: Approximately 50% of the sample showed adequate nutritional status. Most of it showed inadequate caloric and lipid intake. BMI/age was the nutritional indicator that best showed the increased percentage of trunk fat, android/gynecoidratio and trunk fat/total fat ratio. Patients with Pancreatic Insufficiency and eutrophic individuals showed higher median android/gynecoidratio. Conclusion: Increased abdominal adiposity was evidenced by DXA. The BMI did not identify decreased lean body mass. However, when body mass was high, it was significant for abdominal adiposity. The anthropometric assessment of patients with cystic fibrosis should be associated with body composition and body fat distribution to obtain an earlier malnutrition and cardiometabolic risk factor diagnosis.*
Key words *Cystic fibrosis, Abdominal adiposity, Body mass index according to age*

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Introduction

The inadequate nutritional status (NS) is cause for concern because it is associated with increased morbidity and mortality in patients with cystic fibrosis (CF)[1]. The body mass index (BMI), which is commonly used to diagnose NS, does not identify body fat composition or distribution. The Dual-energy X-ray absorptiometry (DXA) is considered to be the gold standard to assess body compartments[2].

Abdominal fat accumulation has been already found in young and adult CF patients even if they show significant total body fat reduction as well as low weight. It is attributed to factors such as chronic inflammation, cortico therapy, physical inactivity and relative growth hormone decrease or anabolic substances found in most of these patients[3].

Increased abdominal fat is associated with cardiovascular risk factors and with peripheral insulin resistance[4]. In addition, it contributes to the development of hepatic steatosis and is negatively related to bone demineralization, which increases in the adolescence of FC patients[5,6].

Although abdominal adiposity is a relevant issue, there are few studies on the body fat distribution in these patients and, so far, there is no national publication on this topic. In addition, there are no studies using DXA to assess body composition in CF children and adolescents.

The disease incidence in Brazil is 1/10,000 live births[7]. It indicates that 1:20 inhabitants carries the CF gene[8]. The 1/6902[9] incidence was estimated in Rio de Janeiro. According to the last Brazilian Cystic Fibrosis Register data[10], approximately 80% of CF patients in Brazil are under 18 years old.

In light of the foregoing and by taking under consideration that these patients survival rate ranges from 30 to 50 years, the current study aims to evaluate the NS and the body fat distribution using DXA in order to highlight the presence of cardiometabolic risks in CF children and adolescents.

Methods

This is a retrospective cross-sectional census-type study conducted at Instituto Nacional da Saúde da Mulher, da Criança e do Adolescente Fernandes Figueira. The Institute is an organ of Fundação Oswaldo Cruz, IFF/Fiocruz, and a CF Reference Center in Rio de Janeiro. The study was conducted in all patients, aged between 8 and 18 years and diagnosed with CF. Pregnant adolescents as well as obese children and adolescents were excluded from the study.

Sixty (60) out of the 120 patients enrolled in the service were initially eligible. They were aged between 8 and 18 years. Four of them were excluded because they had not been subjected to DXA examination during the data collection period (from January 2010 to December 2013). This universe represents74.5% of the CF registered patients in Rio de Janeiro, according to data provided by the last Brazilian Cystic Fibrosis Register/REBRAFC, 2012[10].

The nutritional status evaluation used anthropometric indices such as BMI/A and height according to age (H/A), which were analyzed according to the growth curves by the World Health Organization (WHO) and classified according to the Nutrition Consensus for CF Pediatric Patients[11].

The body fat distribution was assessed by DXA using the Lunar enCORE software -2011, version 13.6, with GE densitometer, *Lunar* iDEXA Promodel. Children and adolescents were instructed to wear light clothes and to remove all metal objects. The measurements were done after the patients were placed in supine position and remained motionless on the scanning bed. After the full body scan, the software provided estimates on fat mass, bone mass and lean mass in the entire body and in specific areas (torso, gynecoid, android, and upper and lower limbs). The android region was measured in the area around the waist, between the midpoint of the lumbar spine and the top of the pelvis. The gynecoid area was measured approximately between the femoral head and the mid-thigh. The software demarcated and separated the limbs from the torso and from the head by standard lines generated by the equipment itself; these lines were adjusted according to specific anatomical points determined by the manufacturer[12]. The body fat percentage (BF %) was calculated by dividing the total body mass by the total body fat, multiplying the result by 100. Based on the image diagnosis, the body fat percentage and torso fat percentage results were analyzed according to the age and gender of all races and ethnicities, following the *National Health and Nutrition Examination Survey* criteria[13]. The image diagnosis provided by DXA allowed investigating the mean fat percentage, the torso fat mass/total fat mass ratio and the android/gynecoid fat ratio.

The 24-hour recall method was used to assess the patients' usual dietary intake. The method

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was applied in three non-consecutive days, with maximum interval of three months, and the data were obtained by means of visual aids and photos of utensils (Household Budget Survey)[14].

The NutWin® software, version 1.5 (2002) was used to calculate the total energy value (TEV), the saturated fat, and the polyunsaturated fat means, by double entry. Trans fat was calculated using data on fresh and processed foods obtained from the food composition tables of the United States Department of Agriculture (USDA) and from the Brazilian Table of Food Composition (*TACO - Tabela Brasileira de Composição dos Alimentos*)[15,16]. The data on the composition of industrial foods and of calorie and protein supplements was collected on the product labels and/or from the manufacturers. The reference standards for energy intake, according to age and gender, were from Food and Agriculture Organization/World Health Organization[17].

The macronutrient intake taken under consideration was 15-20% for protein, 40-50% for carbohydrates, and 35-40% for lipids. The energy adequacy percentage was > 150% of the recommendations, according to the Nutrition Consensus[8]. The intake percentage of total polyunsaturated fatty acids (PUFA), saturated fatty acids (SFA), and trans fat in comparison to TEV was evaluated according to the WHO[18].

Statistical Analysis

The means and standard deviations of the continuous variables were presented in the descriptive analysis with normal distribution and in median, minimum and maximum values for those without normal distribution. Normality was verified using the Kolmogorov-Smirnov test. Categorical variables were described by absolute and percentage frequencies. Pearson chi-square tests and Fisher's exact test were used to measure the association among categorical variables, in cases in which at least one expected frequency lower than five was observed. When the normality assumption was confirmed, Student's t test and variance analysis (ANOVA) were used to compare the continuous measurements between two and among three (or more) groups, respectively. When normality was not confirmed, the Mann-Whitney and the Kruskal-Wallis tests were used in variables with two and with three or more categories, respectively. Pearson and Spearman correlation tests were used in variables with and without normal distribution, respectively, to measure the degree of association between continuous variables. Univariate regression models containing each of the independent variables were evaluated to identify possible associations between the explanatory variables and the outcomes. All significant variables at 20% level in the univariate analysis were considered to be possible predictors in the multiple regression. Statistical tests were performed at 5% significance level. The analyses were conducted in SPSS software, version 20 (SPSS Corporation, 2011) and in R software, version 3.0.

The current study was approved by the Research Ethics Committee of at Instituto Nacional da Saúde da Mulher, da Criança e do Adolescente Fernandes Figueira/Fiocruz.

Results

Fifty-six (56) patients with mean age of 12.2 (± 2.5) years were studied. Most were women and showed exogenous pancreatic insufficiency (EPI). Approximately 50% of the cases had at least one allele for the F508 mutation The nutritional status was considered to be acceptable at 50% (BMI/A) and at 83% (H/A) (Table 1).

Energy and lipid intake was considered inadequate in more than 80.0% of the studied population. The consumption of saturated and trans fat met the recommendations for most patients.

Adolescents aged 16-19 years showed the highest percentage of torso fat and those aged 12-15 years showed the highest percentage of total fat (Table 1). BMI/A was the only statistically significant variable in the bivariate analysis of the torso fat percentage evaluation.

Regarding the bivariate analysis of the total fat percentage and of the torso fat percentage, no statistically significant result ($p < 0.05$) was found in any studied variable.

The results from the bivariate analysis of android/gynecoid fat ratio demonstrated that the pancreatic function and the BMI/A variables were statistically significant ($p < 0.05$) (Table 2).

The bivariate analysis of the torso fat/ total fat ratio showed that the age, BMI/A and TEV variables were statistically significant ($p < 0.05$). It was observed that older patients with improved nutritional status showed higher torso fat/total fat ratio. Patients with inadequate TEV (< 150%) showed higher meant or so fat/total fat ratio (0.36 ± 0.06) (Table 3).

Age and nutritional status (BMI/A) were statistically significant variables ($p < 0.05$) in the multiple regression analysis of the torso fat/ to-

Table 1. Demographic, clinical and nutritional features of children and adolescents with Cystic Fibrosis, 2010-2013 (IFF/Fiocruz - RJ) (n = 56).

Clinical features	N (%)
Age	
8-11 years old	14 (25.0)
12-15 years old	24 (42.8)
16-19 years old	18 (32.14)
Genotype	
DF508/DF508	8 (14.3)
DF508/others	19 (33.9)
N/N	10 (17.9)
Others/others	19 (33.9)
BMI / A (percentile)	
< 10	12 (21.4)
10-25	15 (26.8)
> 25	29 (51.8)
H / A (percentile)	
< 5	9 (16.1)
≥ 5	47 (83.9)
Food intake (TEV)	
< 150%	45 (80.4)
≥ 150%	11 (19.6)
Carbohydrates	
< 40% TEV	9 (16.1)
40-50% TEV	31 (55.4)
> 50% TEV	16 (28.6)
Proteins	
<15% TEV	13 (23.2)
15-20% TEV	28 (50.0)
> 20% TEV	15 (26.8)
Lipids	
< 35% TEV	50 (89.3)
35-40% TEV	5 (8.9)
> 40% TEV	1 (1.8)
Fatty acids	
saturated < 8%	43 (76.8)
≥ 8%	13 (23.2)
trans < 1% TEV	48 (85.7)
≥ 1% TEV	8 (14.3)
DXA	**Med (Min-Max)**
% Torso Fat	16.1 [6.9-53.4]
8-11 years old	14.45 [6.9-41.9]
12-15 years old	17.15 [8.7-53.4]
16-19 years old	17.6 [8.1-33.5]
% Total Fat	21.8 [9.0-48.0]
8-11 years old	20.7 [13.8-43.5]
12-15 years old	23.2 [10.4-48.0]
16-19 years old	21.8 [9.0-35.2]
Android/gynecoid fat ratio	0.22 [0.10-0.62]
	Mean/ SD
Torso fat/total fat ratio	0.36 ± 0.07

DF508: Delta/F 508 mutation; N / N; unidentified mutation; EPI: exocrine pancreatic insufficiency; EPS: exocrine pancreatic sufficiency; BMI / A: body mass index for age; H / A: height for age; TEV: total energy value; DXA: dual energy X-ray absorptiometry IFF: Instituto Nacional Saúde da Mulher da Criança e do Adolescente Fernandes Figueira. Fiocuz: Fundação Oswaldo Cruz. Values expressed in n (%), mean ± SD or median [minimum and maximum].

Table 2. Bivariate analysis of the android/gynecoid fat ratio using the variables of interest in children and adolescents with cystic fibrosis, 2010-2013(IFF/ Fiocruz-RJ) (n = 56).

Variables	n	median (min-max)	p value
Age			0.156
8-11 years old	14	0.20 [0.10-0.51]	
12-15 years old	24	0.23 [0.14-0.62]	
16-19 years old	18	0.24 [0.19-0.51]	
Gender			0.876
Male	24	0.22 [0.10-0.51]	
Female	32	0.21 [0.14-0.62]	
Genotype			0.805
DF508/DF508	8	0.22 [0.17-0.51]	
DF508/others	19	0.23 [0.10-0.51]	
N/N	10	0.20 [0.15-0.32]	
Others/Others	19	0.22 [0.14-0.62]	
Pancreatic function			0.044*
EPI	36	0.23 [0.10-0.51]	
Ethnicity			0.577
White	48	0.22 [0.10-0.62]	
Afro-descendant	1	0.20 [0.20-0.20]	
Asian	0	0	
Mulatto	7	0.26 [0.14-0.35]	
BMI / A			0.003*
< p10	12	0.19 [0.10-0.29]	
p10-25	15	0.21 [0.14-0.38]	
> p25	29	0.24 [0.15-0.62]	
H / A			0.343
< p5	9	0.20 [0.10-0.47]	
≥ p5	47	0.22 [0.14-0.62]	
Food Intake			
TEV			0.101
< 150%	45	0.23 [0.14-0.62]	
≥ 150%	11	0.21 [0.10-0.38]	
Carbohydrates			0.429
< 40% TEV	9	0.24 [0.16-0.51]	
40-50% TEV	31	0.22 [0.10-0.62]	
> 50% TEV	16	0.21 [0.15-0.47]	
Proteins			0.515
< 15% TEV	13	0.21 [0.19-0.51]	
15-20% TEV	28	0.22 [0.10-0.51]	
> 20% TEV	15	0.24 [0.14-0.62]	
Lipids			0.455
< 35% TEV	50	0.22 [0.10-0.62]	
35-40% TEV	5	0.24 [0.20-0.38]	
> 40% TEV	1	0.19 [0.20-0.20]	
Fatty acids			
saturated < 8%	43	0.23 [0.10-0.51]	0.479
≥ 8%	13	0.21 [0.14-0.62]	
trans < 1% TEV	48	0.22 [0.10-0.62]	0.558
≥ 1% TEV	8	0.20 [0.19-0.28]	

DF508: Delta/F 508 mutation; N / N; unidentified mutation; EPI: exocrine pancreatic insufficiency; EPS: exocrine pancreatic sufficiency; BMI / A: body mass index for age; H / A: height for age; TEV: total energy value; IFF: Instituto Nacional Saúde da Mulher da Criança e do Adolescente Fernandes Figueira. Fiocuz: Fundação Oswaldo Cruz.
* $p<0.05$

Table 3. Bivariate analysis of the torso fat/total fat ratio using the variables of interest in children and adolescents with cystic fibrosis, 2010-2013 (IFF/Fiocruz) (n = 56).

Variables	n	Mean ± SD	p value
Age			0.006*
8-11 years old	14	0.31 ± 0.06	
12-15 years old	24	0.36 ± 0.07	
16-19 years old	18	0.39 ± 0.04	
Gender			0.182
Male	24	0.34 ± 0.06	
Female	32	0.36 ± 0.06	
Genotype			0.946
DF508/DF508	8	0.36 ± 0.06	
DF508/others	19	0.36 ± 0.07	
N/N	10	0.35 ± 0.04	
Others/Others	19	0.35 ± 0.08	
Pancreatic function			0.927
EPI	36	0.37 ± 0.06	
EPS	20	0.34 ± 0.08	
Ethnicity			0.493
White	48	0.35 ± 0.07	
Afro-descendant	1	0.28 ± 0.00	
Asian	0	0	
Mulatto	7	0.37 ± 0.04	
BMI/A			0.001*
< p10	12	0.30 ± 0.05	
p10-25	15	0.34 ± 0.05	
> p25	29	0.38 ± 0.06	
H/A			0.156
< p5	9	0.32 ± 0.07	
≥ p5	47	0.36 ± 0.06	
Food Intake			
TEV			0.011*
< 150%	45	0.36 ± 0.06	
≥ 150%	11	0.31 ± 0.06	
Carbohydrates			0.542
< 40% TEV	9	0.37 ± 0.06	
40-50% TEV	31	0.35 ± 0.06	
> 50% TEV	16	0.34 ± 0.06	
Proteins			0.111
< 15% TEV	13	0.36 ± 0.06	
15-20% TEV	28	0.33 ± 0.06	
> 20% TEV	15	0.38 ± 0.07	
Lipids			0.519
< 35% TEV	50	0.35 ± 0.07	
35-40% TEV	5	0.37 ± 0.05	
> 40% TEV	1	0.29 ± 0.00	
Fatty acids			
Saturated			0.790
< 8%	43	0.36 ± 0.07	
≥ 8%	13	0.35 ± 0.07	
Trans			0.581
< 1% TEV	48	0.35 ± 0.07	
≥ 1% TEV	8	0.37 ± 0.04	

DF508: Delta/F 508 mutation; N / N; unidentified mutation; EPI: exocrine pancreatic insufficiency; EPS: exocrine pancreatic sufficiency; BMI / A: body mass index for age; H / A: height for age; TEV: total energy value; Values expressed in mean ± SD or median [minimum and maximum IFF: Instituto Nacional Saúde da Mulher da Criança e do Adolescente Fernandes Figueira. Fiocuz: Fundação Oswaldo Cruz. *p < 0,05

tal fat ratio of children and adolescents with CF, (Table 4). The multiple regression analysis of the android/gynecoid fat ratio found that the BMI/A and the carbohydrate intake were statistically significant variables (p < 0.05) (Table 5).

Discussion

The current study found that only 50% of the patients showed adequate nutritional status (BMI/A > p 25). This result is relevant because the peripuberal period is one of the most important stages in the disease's treatment[11]. Patients followed up in reference centers in the United States are closer or above the 50th percentile for the BMI/A indicator, which is the current nutritional treatment goal due to the strong association between nutritional status and lung function[1].

Table 4. Multiple linear regression analysis of the torso fat/total fat ratio in children and adolescents with cystic fibrosis, 2010-2013(IFF/Fiocruz-RJ) (n = 56).

Variables	Estimate (CI 95%)	p value
Age		
8-11 years old	--	--
12-15 years old	0.04 (-0.01 ; 0.08)	0.10
16-19 years old	0.06 (0.01 ; 0.10)	0.02*
Gender		
Male	--	--
Female	0.03 (-0.00 ; 0.06)	0.09
Pancreatic function		
EPI	0.00 (-0.03 ; 0.04)	0.88
EPS	--	--
BMI/A		
< p10	-0.07 (-0.11 ; - 0.02)	0.01*
p10-25	-0.04 (-0.08 ; - 0.00)	0.03*
> p25	--	--
H/A		
< p5	-0.03 (-0.08 ; 0.02)	0.22
≥ p5	--	--
TEV		
< 150	0.04 (-0.01 ; 0.08)	0.10
≥ 150	--	--
Proteins (intake)		
< 15% TEV	-0.01 (-0.05 ; 0.03)	0.63
15-20% TEV	--	--
> 20% TEV	-0.01 (-0.06 ; 0.03)	0.57

EPI: exocrine pancreatic insufficiency; EPS: exocrine pancreatic sufficiency; BMI/A: body mass index for age; H/A: height for age; TEV: total energy value; IFF: Instituto Nacional Saúde da Mulher da Criança e do Adolescente Fernandes Figueira. Fiocuz: Fundação Oswaldo Cruz.
* p < 0.05

Table 5. Multiple linear regression analysis of the android/gynecoid fat ratio logarithm in children and adolescents with cystic fibrosis, 2010-2013 (IFF/Fiocruz – RJ) (n = 56).

Variables	Estimate (CI 95%)	p value
Age		
8-11 years old	--	--
12-15 years old	0.12 (-0.12 ; 0.36)	0.33
16-19 years old	0.03 (-0.23 ; 0.29)	0.82
Pancreatic function		
EPI	0.02 (-0.17 ; 0.21)	0.82
EPS	--	--
BMI/A		
< p10	-0.39 (-0.63 ; -0.15)	0.00*
p10-25	-0.27 (-0.49 ; -0.04)	0.02*
> p25	--	--
TEV		
< 150%	0.20 (-0.40 ; 0.45)	0.10
≥ 150%	--	--
Carbohydrates (intake)		
< 40% TEV	0.25 (0.00 ; 0.50)	0.05*
40-50% TEV	--	--
> 50% TEV	0.00 (-0.20 ; 0.20)	0.99

EPI: exocrine pancreatic insufficiency; EPS: exocrine pancreatic sufficiency; BMI/A: body mass index for age; TEV: total energy value; IFF: Instituto Nacional Saúde da Mulher da Criança e do Adolescente Fernandes Figueira. Fiocuz: Fundação Oswaldo Cruz.
* $p < 0.05$

It was observed that approximately 50% of the patients had at least one allele for the F508 mutation. This result corroborates the last Brazilian Cystic Fibrosis Register (REBRAFC, 2012)[10]. This mutation is the most frequent one and it has more severephenotype[19]. Thus, patients with this mutation show greater chance of malnutrition[20]. This fact may explain the percentage of under nourished patients found in the current study.

A relevant aspect found in the current study was the fact that most patients (83.9%) had no short height, which shows good linear growth. Another study also found similar results[21]. It is worth highlighting that short height affects survival, since it influences lung growth and development. Thus, it is considered to be an important and independent risk factor for mortality in CF patients, because it requires nutritional rehabilitation, which is usually long, invasive and expensive[22].

As for the body composition, there was 48% decrease and 9% increase in total body fat percentage. Although the current study did not investigate the lean body mass, one can infer that it was quite impaired. Since patients with inadequate BMI showed normal body fat percentage, it means that they had lean mass depletion. It happens because once BMI does not identify body compartments, it is unable to track subtle changes in the body composition[23].

The current study found that most of the studied sample ingested less than 150% of the recommended energy intake, showing little adhesion to the nutritional treatment or anorexia, which is commonly found in these patients. This result meets the research conducted by Schall et al. who observed that only 28% of the sample ingested the recommended minimum energy intake[24].

Regarding lipids, 89% of the studied population ingested less than the recommended amount. These results were also found in other studies[21,24]. These data demonstrate that despite the nutritional counseling received in the Reference Center, CF patients showed difficulty in achieving the recommendations. This is concerning because according to a classic study on the differences in mean survival and growth parameters of patients from two major CF Reference Centers (Boston and Toronto), those with more adequate NS showed greater nutritional intake of lipids[25].

It is worth emphasizing that lipids are the main source of energy in food and that they have important metabolic functions. In addition, CF shows deficiency and imbalance of essential fatty acids (EFA)[26,27].

The analysis of the trans fatty acid intake (trans FA) percentage was adequate (< 1% TEV), according to the WHO/FAO (2008) recommendations for the prevention of chronic diseases in most patients[18]. It is relevant because the high trans fatty acids consumption associated with low EFA intake is harmful due to enzymes competition in the enzymatic cascade for long-chain metabolites biosynthesis[28]. The low trans-fat consumption in the studied sample may result from instructions received in consultations with the dietician or from the reduction of this fat in processed foods, as established by the Ministry of Health in 2006.

The saturated fatty acids (SFA) intake percentage was also adequate in most of the studied patients. This result differs from that found by Smith et al.[29] who reported high SFA intake among CF children. It is important because the systemic inflammatory reaction is a risk factor

for a thermogenesis and once associated with high SFA intake it increases the risk of cardiovascular diseases[28,30].

The carbohydrate intake was statistically significant in the torso fat percentage, possibly because although most patients have consumed normal carbohydrate percentages, this consumption might have been based on simple carbohydrates. The software used to assess food intake (*Nutwin*) does not separate simple from complex carbohydrates.

Approximately 9% of the studied sample showed increased torso fat, and it was higher in older and male patients. It possibly occurred because central obesity tends to increase due to aging – it begins in childhood and in adolescence and continues in adulthood – and due to the male gender tendency to accumulate fat in this region[31]. Therefore, the patients in the current study were stratified by different age groups between genders, based on the differentiation of the sexual maturation process in which important changes in fat and lean mass compartments differently occur.

Since these patients already show survival rate ranging from 30 to 50 years and since there is ample evidence that risk factors that begin in childhood and adolescence are perpetuated into adulthood, the current result is concerning because increased torso fat leads to increased abdominal and visceral fat and this is a predictor of increased risk of cardiometabolic diseases. The endocrinal and inflammatory function of the fat tissue located in the abdominal cavity causes increased secretion of pro-inflammatory and atherogenic adipokines, free fatty acids and inflammatory markers. It also causes circulating adiponectin decrease, which in turn seems to lead to dyslipidemia, insulin resistance and vascular inflammation[32].

The produced pro inflammatory adipokines are also negatively related to bone demineralization and hepatic steatosis, which occur in CF patients[5,6]. Since applying biomarkers to establish the overall risk and performing early diagnosis to prevent cardiovascular events are still a challenge, metabolic changes may be early identified in central obesity patients using DXA[33].

Moriconi et al.[34] studied the evaluation of body fat composition and distribution in adult CF patients using DXA and also found increased abdominal fat even in patients with low weight.

The current study demonstrated that approximately 9% of the patients showed total body fat increase. This result may due to changes in living habits – which were seen in the general population – or to the use of high-calorie supplements, diet by gastrostomy and to enteral nutrition, because obesity is unusual in CF patients, since the disease is characterized by negative energy balance. The significant increase in the prevalence of overweight and obesity in many countries, including Brazil, turns obesity into a major public health issue affecting all age groups. Epidemiological evidence has demonstrated that the relation between obesity and the risk of cardiometabolic diseases is perceived both earlier in life and during the individuals' growth and development[35-37].

The results in the current study showed that the BMI/A was statistically significant in torso fat percentage. Patients presenting poorer nutritional status showed the lowest torso fat accumulation, as it usually occurs in children and adolescents without CF. However, Panagopoulou et al.[3] found abdominal fat accumulation in young and adult CF patients, even in the presence of significant total body fat reduction. These authors suggested that the responsible factors are chronic inflammation, cortico therapy, physical inactivity, relative growth hormone decrease or anabolic substances. Other chronic inflammatory diseases also show increased abdominal fat distribution associated with chronic inflammatory condition, insulin resistance and cardiovascular risk.

There was higher android/gynecoid fat ratio in the presence of EPI. It may have happened because EPI is usually associated with worse phenotype, which is probably associated with chronic inflammation that may cause abdominal fat accumulation. This increased ratio in adolescents and adults accounts for the higher risk of metabolic and cardiovascular complications.

A limitation of the current study lies on the fact that, since it is across-sectional analysis, it points only to associations, without establishing a cause-effect relationship. In addition, the disease severity varies in these patients, thus making the population more heterogeneous. The lack of cut-off point for the android-gynecoid ratio and for the total torso ratio in the DXA also hinders the data analysis.

Conclusion

Although 50% of the cases showed nutritional status adequacy by BMI/A, this percentage would be lower if the lean body mass had been assessed. Most patients presented an inappropriate energy

and lipids consumption, thus showing little adherence to the nutritional treatment. However, it was observed adherence to the contemporary society diet with exaggerated carbohydrate intake.

Increased abdominal adiposity was evidenced by the DXA. It is a fast and easy examination, which exposes individuals to small radiation doses. Thus, the body composition and the body fat distribution of CF patients should be evaluated during their nutritional follow-up in order to early diagnose malnutrition and cardiometabolic risk factors.

Collaborations

CRMM Chaves participated in the conception and design of the study, analysis and interpretation of data, writing or critical review of the relevant intellectual content of the manuscript; responsibility for all aspects of work, including ensuring its accuracy and integrity. AC Costa was responsible for the analysis and interpretation of data and writing or relevant critique of the intellectual content of the manuscript review. ALP Cunha was responsible for final approval of the version to be published, and all aspects of work, including ensuring its accuracy and integrity. RSS Costa was responsible for final approval of the version to be published, and all aspects of work, including ensuring its accuracy and integrity. SV Lacerda participated in the conception and design of the study, analysis and interpretation of data and critical review of the relevant intellectual content of the manuscript.

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