Body composition changes in asthmatic children regarding steroid therapy duration

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Background

Childhood asthma is markedly increasing in developing countries. The first line of management according to national asthma guidelines is inhaled corticosteroids. Accurate body composition analysis, with persistent asthma control by steroid therapy, is essential in childhood, as the potential effects of the long-term and short-term treatments are still a matter of concern.

Aim

To assess the body composition (total and regional) distribution in Egyptian children with asthma receiving inhaled steroid with different duration therapy.

Patients and methods

Body composition was measured by dual-energy X-ray absorptiometry in a cross-section study of 160 Egyptian prepubertal school-aged children (4–12 years). There were 60 asthmatic children controlled by long-term steroid therapy and 60 asthmatics controlled by short-term steroid therapy, who were compared with 40 healthy children to assess the effect of duration of therapy.

Results

Asthmatic children controlled by long-term steroid therapy had significantly higher weight, BMI, and total and chest lean masses among both sexes within all different age groups ($P<0.05$). However, asthmatic female children controlled by long-term therapy had significantly higher total and pelvic fat masses rather than both short-term and healthy groups ($P<0.05$). Moreover, the body composition parameters (total and regional) had positive significant correlations with BMI.

Conclusion

The total lean mass, specifically chest lean mass, is increased in asthmatic children who are controlled by long-term steroid therapy, and evaluation of those children using dual-energy X-ray absorptiometry provides an accurate analysis of both total and regional body composition.

Keywords:
asthma, body composition, dual-energy X-ray absorptiometry, steroids

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Introduction

Childhood asthma is the most common chronic inflammatory disease of the lung [1,2]. It is characterized by inflammation of the airway, with episodes of coughing, wheezing, and shortness of breath [3]. Proper diagnosis of asthma is essential for the management, to detect accurate treatment and its dose [4]. Asthma cannot be cured, but it can be controlled by medications to reduce symptoms during acute attacks [5]. National guidelines recommend long-term inhaled corticosteroids (ICS) therapy as a standard treatment of childhood asthma, to reduce its mortality and morbidity, as well as to improve quality of life [6,7]. Hence, the effects of long-term ICS therapy on asthmatic children must be clearly defined. Analysis of body composition is essential for clinical and research settings [8]. Most studies on asthma have concentrated on obesity while using BMI as an indicator of high fat; however, BMI cannot differentiate between muscle (lean) and fat masses, and also it cannot measure fat distribution but can only indicate fatness in the whole body [9–12]. Therefore, dual-energy X-ray absorptiometry (DEXA) provides an accurate assessment of body composition at the tissue level [8]. Careful consideration of the body composition changes and differentiation between fat and lean body masses may be an important factor in asthmatic children [13,14]. The current study aimed to assess the total and regional body composition (lean and fat masses) in Egyptian children with asthma receiving ICS with different duration therapy.

Patients and methods

Design

A cross-sectional study design was adopted.

Participants

A total of 160 prepubertal school-aged Egyptian children of both sexes were included in this study. Their ages were ranged from 4 to 12 years. They were subdivided according to their ages into three groups: 4–6, 6.1–9, and 9.1–12 years. The first age group included 52 children (36 males and 16 females), the second age group included 58 children (36 males and 22 females), whereas the third one included 50 children (26 males and 24 females). The children were diagnosed with asthma, which was defined by a physician. They had episodic respiratory symptoms in the past 12 months, and children received ICS of 200–400 μg budesonide a day. Then they were assigned to one of the following three groups: 60 asthmatic children received long-term steroid therapy (for 2 years) in the first group, 60 asthmatic children received short-term steroid therapy (for >6 months) in the second group, and 40 healthy children who never had asthma or were taking any medications were included in the third group. Exclusion criteria included inflammatory diseases, respiratory disorders other than asthma, metabolic or cardiac diseases, or unexplained weight change during the past 3 months. This study was approved by the research ethics committee of the faculty of physical therapy of Cairo University (P.T. REC/012/002002), and a written informed consent was signed by the parent of each child. The study procedures were conducted between April 2018 and January 2019, at the Medical Research Centre of Excellence, National Research Centre, Giza, Egypt.

Evaluation of children included the following:

Anthropometric measurements: the body weight and height were taken following the international biological program recommendations [15]. A Seca scale balance was used to assess body weight to the nearest 0.01 kg while the child wears light clothes and no shoes, and then Holtain portable anthropometer was used to measure height to the nearest 0.1 cm. Then BMI was calculated as weight (kg) divided by height (m^2).

DEXA scan: total body scan was conducted using Norland XR-46, (version 3.9.6/2.3.1, USA, America); children were scanned in the appropriate position, and then manual adjustments were made to ensure that whole-body regions were located within the set parameters. Software analysis calculated the total body composition (percentage and mass). The final data included total and regional lean and fat masses.

Statistical analysis

Data were analyzed using statistical package for the social sciences (version 25, IBM Corporation, USA). Parametric data were expressed as mean±SD, and one-way analysis of variance was used to compare three groups while using a Fisher's least significant difference post-hoc test. Pearson's correlation test was used to examine the association and correlation, as well as scatter plots were done. Statistical significance was set at P value less than 0.05.

Results

The present study included three groups: 60 children with asthma controlled by long-term steroid therapy (37 males and 23 females), 60 children with asthma used short-term steroid therapy (29 males and 31 females), and 40 healthy children (23 males and 17 females). Regarding change body composition with growth, the data were represented by age groups for both sex (4–6, 6.1–9, and 9.1–12 years) to detect accurate result.

The means and SD of the anthropometric measurements and significant body compositions values (lean mass and fat mass) among three groups (asthmatic controlled by long-term steroid therapy, asthmatic controlled by short-term steroid therapy and the healthy group) were calculated for each age group.

Regarding the age group 4–6 years, asthmatic children controlled by long-term steroid therapy had a significantly higher weight, BMI, and total and chest lean masses than both asthmatic controlled by short-term steroid therapy and healthy children of both sexes. Additionally, the female children controlled by long-term steroid therapy had significantly higher total and pelvic fat masses ($P<0.05$) (Table 1).

Regarding the age group 6.1–9 years, asthmatic children controlled by long-term steroid therapy had significantly higher parameters like the previous age group (4–6 years). Additionally, they had higher total fat mass in both sexes and significantly higher pelvic fat mass in female children only (Table 2); however, asthmatic male children controlled by short-term steroid therapy had significantly higher

Table 1 Means and SD of the anthropometric measurements and body compositions between three groups (asthmatic controlled by long-term steroid therapy, short-term steroid therapy, and healthy group) for age 4–6 years

	Sex	Asthmatic controlled by long-term steroid therapy (mean±SD)	Asthmatic controlled by short-term steroid therapy (mean±SD)	Healthy (mean ±SD)	*P* value
Anthropometric measurement					
Weight (kg)	Male	22.9±2.8	19.6±2.9[a]	19.1±4.1[a]	0.025*
	Female	18.8±1.2	17.5±3.1	16.3±2.5[a]	0.055*
Height (cm)	Male	116.7±4.3	112.6±6.1	112.1±6.3	0.284
	Female	116.6±3.5	113.2±6.0	113.1±4.5	0.748
BMI (kg/m^2)	Male	16.8±2.0	15.2±1.5[a]	15.0±0.7[a]	0.029*
	Female	14.7±4.7	13.2±1.2[a]	12.3±1.2[a]	0.043*
Body composition					
Total lean (kg)	Male	14.4±2.5	12.0±3.0	9.8±3.8[a]	0.016*
	Female	13.1±1.8	12.1±1.7	10.4±2.6[a]	0.021*
Chest lean (kg)	Male	3.1±0.9	2.6±0.9	1.9±1.0[a]	0.051*
	Female	3.8±0.4	3.1±0.4	2.8±0.8[a]	0.040*
Pelvis lean (kg)	Male	2.9±0.4	2.5±0.5	2.5±1.0	0.272
	Female	2.6±0.6	2.4±1.0	2.3±0.8	0.879
Total fat (kg)	Male	8.5±3.8	8.6±1.5	7.1±2.0	0.494
	Female	8.3±2.3	5.6±1.0[a]	4.6±1.7[a]	0.022*
Chest fat (kg)	Male	2.4±0.5	1.6±1.0	1.8±0.5	0.391
	Female	1.8±0.8	1.1±0.7	1.1±0.6	0.597
Pelvis fat (kg)	Male	2.8±1.9	2.4±2.7	1.0±0.7	0.161
	Female	5.8±1.4	3.7±0.2[a]	2.6±0.3[a]	0.000*

[a]*P* value less than or equal to 0.05 relative to asthmatic controlled by a long-term steroid therapy group. [b]*P* value less than or equal to 0.05 relative to asthmatic controlled by a short-term steroid therapy group. *Significant ($P\leq0.05$).

Table 2 Means and SD of the anthropometric measurements and body compositions among the three groups (asthmatic controlled by long-term steroid therapy, short-term steroid therapy, and healthy group) for age 6.1–9 years

	Sex	Asthmatic controlled by long-term steroid therapy (mean±SD)	Asthmatic controlled by short-term steroid therapy (mean±SD)	Healthy (mean±SD)	*P* value
Anthropometric measurements					
Weight (kg)	Male	32.5±8.6	26.8±5.5	21.7±3.8[a]	0.027*
	Female	28.5±4.4	26.5±7.2	23.7±2.5[a]	0.053*
Height (cm)	Male	122.8±6.5	117.6±6.5	120.5± 7.5	0.966
	Female	124.0±5.6	124±3.6	121.2±3.1	0.298
BMI (kg/m^2)	Male	21.5±6.7	16.1 ±2.3	14.8±1.5[a]	0.017*
	Female	18.5± 2.8	17.9±5.9	16.8±2.4[a]	0.040*
Body composition					
Total lean (kg)	Male	17.5±5.4	14.8±5.7	12.4±3.3[a],b	0.048*
	Female	19.2±2.1	18.7±2.5	16.5±4.4[a]	0.049*
Chest lean (kg)	Male	4.0±1.4	3.3±1.4	2.2±0.6[a],b	0.005*
	Female	4.5±0.4	3.8±0.8	3.6±1.2[a]	0.039*
Pelvis lean (kg)	Male	3.1±1.0	2.9±0.6	2.8±0.5	0.571
	Female	3.7±0.1	3.6±0.5	2.8±0.7	0.248
Total fat (kg)	Male	15.7±5.1	9.6±1.6	7.9±1.2[a]	0.017*
	Female	10.4±4.2	8.1±0.3	7.8±3.4[a]	0.039*
Chest fat (kg)	Male	4.0±3.6	2.0±0.7	2.7±0.8	0.337
	Female	2.4±1.2	1.9±0.4	2.4±0.7	0.978
Pelvis fat (kg)	Male	2.4±0.8	2.3±2.6	1.7±2.0	0.517
	Female	2.9±3.1	1.6±0.5	1.4±0.7[a]	0.027*

[a]*P* value less than or equal to 0.05 relative to asthmatic controlled by a long-term steroid therapy group. [b]*P* value less than or equal to 0.05 relative to asthmatic controlled by a short-term steroid therapy group. *Significant ($P\leq0.05$).

total and chest lean masses than the healthy children ($P<0.05$).

Regarding the age group 9.1–12 years, male asthmatic children controlled by long-term steroid therapy had a significantly higher weight and total, chest, and pelvic lean masses than both other groups. However, female asthmatic children controlled by long-term steroid therapy had significantly higher total fat mass and pelvic lean mass than other groups (Table 3).

Table 3 Means and SD of the anthropometric measurements and body compositions among three groups (asthmatic controlled by long-term steroid therapy, short-term steroid therapy, and healthy group) for age 9.1–12 years

	Sex	Asthmatic controlled by long-term steroid therapy (mean±SD)	Asthmatic controlled by short-term steroid therapy (mean±SD)	Healthy (mean±SD)	*P* value
Anthropometric measurement					
Weight (kg)	Male	39.1±3.8	33.8±4.7	26.9±6.9[a]	0.036*
	Female	35.0±6.4	35.1±4.9	30.0±6.5	0.379
Height (cm)	Male	134.3±4.3	128.2±5.8	126.1±6.7	0.630
	Female	133.5±4.5	131.2±5.5	127.8±5.1	0.568
BMI (kg/m^2)	Male	20.7±4.1	18.9±3.5	17.3±1.8	0.206
	Female	21.6±4.0	19.7±3.8	17.1±2.1	0.241
Body composition					
Total lean (kg)	Male	27.7±4.2	20.8±3.4	18.8±4.1[a]	0.014*
	Female	22.1±4.0	21.0±3.0	19.9±3.6	0.620
Chest lean (kg)	Male	6.7±0.8	4.7±1.5[a]	3.9±1.6[a]	0.000*
	Female	4.7±0.7	4.7±1.3	4.6±1.2	0.986
Pelvis lean (kg)	Male	5.2±0.6	4.2±0.2	3.5±1.2[a]	0.035*
	Female	4.2±0.4	4.1±0.2	3.7±0.7[a]	0.043*
Total fat (kg)	Male	12.9±3.7	12.1±3.7	11.7±3.8	0.944
	Female	14.9±3.2	13.9±3.9	10.5±3.1[a]	0.052*
Chest fat (kg)	Male	3.2±0.5	3.0±1.5	2.9±1.0	0.966
	Female	3.7±1.1	3.4±1.5	2.7±1.0	0.426
Pelvis fat (kg)	Male	1.9±0.9	1.6±0.7	1.5±0.8	0.817
	Female	1.9±0.8	1.4±0.9	1.2±0.4	0.473

[a]*P* value less than or equal to 0.05 relative to asthmatic controlled by a long-term steroid therapy group. [b]*P* value less than or equal to 0.05 relative to asthmatic controlled by a short-term steroid therapy group. *Significant ($P \leq 0.05$).

Table 4 Association between body compositions (lean and fat masses) with anthropometric measurements

	Total lean (*r*)	Chest lean (*r*)	Pelvis lean (*r*)	Total fat (*r*)	Pelvic fat (*r*)
Weight					
Male	0.84*	0.74*	0.81	0.79*	0.65*
Female	0.81*	0.56*	0.63	0.89*	0.58*
Height					
Male	0.90*	0.86	0.88	0.44*	0.73
Female	0.58*	0.21	0.66	0.52*	0.81
BMI					
Male	0.58*	0.45*	0.53*	0.87*	0.63*
Female	0.63*	0.55*	0.37*	0.76*	0.82*

r, Pearson's correlations.**Correspondence to Correlation is significant ($P>0.05$).

Then partial correlations were done between body composition parameters (total, chest, and pelvic lean masses and total and pelvic fat masses) and anthropometric parameters (weight, height, and BMI), with controlling effect of age (Table 4). The total lean and fat masses had positive significant correlations with weight, height, and BMI ($P<0.05$). The chest and pelvic lean masses also showed positive significant correlations with weight and BMI ($P<0.05$). For the pelvic fat mass, there was a significant positive correlation with BMI.

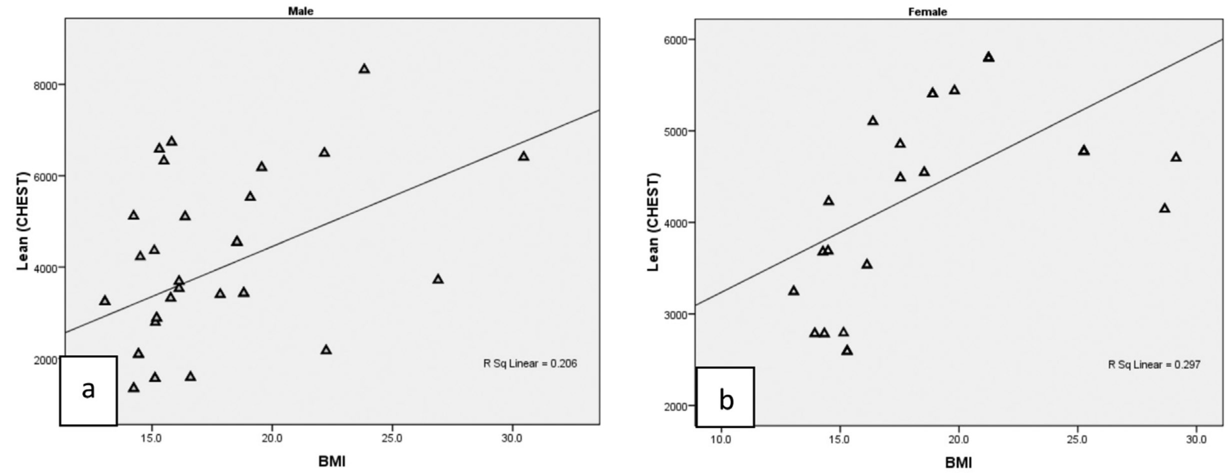
Finally, scatter plot (Fig. 1) was done between chest lean mass and BMI for both sexes and (a and b) showed statistically significant correlation (r=0.21 and 0.29) for male and female, respectively ($P<0.05$).

Discussion

Asthma represents a serious chronic health condition with a high prevalence, which has been studied in many research studies and systematic reviews [16–19], as it is still considered one of the most important noncommunicable diseases worldwide [20]. More than 330 million persons have asthma [21]. Its prevalence in Egypt among children (3–15 years) is 8.2% [22].

Obesity is considered a significant risk factor of asthma, although some studies reported a significant association between both of them [23–27], as more frequent symptoms with severe exacerbations could be detected in obese children, with reduced response to medications

Figure 1



Scatter plot shows the statistically significant correlation between BMI and chest lean (r=0.21 and 0.29 for males (a) and females (b), respectively).

as well [28]. The excess fat mass and lean mass increase the risk of asthma [5]. Careful consideration of the body composition changes during growth and development of a child is essential for the prediction of obesity and other health risks later in life [10–13].

DEXA is used to analyze body composition based on a three-compartment model: the fat mass, the lean mass, and the bone mass. Every compartment has a unique density and attenuates different energy beams, allowing accurate quantification of each tissue with a convenient analysis of the whole and regional body composition [14,29]. Differences of body composition are detected among sex (males and females) at all ages, which emerge at adolescence, with a greater fat mass within females, whereas lean mass was more prominent within males [30].

Few studies have assessed the lean mass and total and regional distribution in children [14,31,32]. Some research studies have indicated the importance of studying thoracic adiposity in asthmatic adults [10,27].

The result of the current study revealed that the weight and BMI were increased within Egyptian asthmatic children who received long-term ICS in age groups 4–6 and 6.1–9 years, whereas only weight was significantly higher in the older age group (9.1–12 years). There was a difference in body lean and fat mass distribution within the age, as well between the sexes. In this study, it was found that the total and chest lean masses were increased within Egyptian asthmatic children who received long-term ICS therapy in the three age groups for both sexes; additionally, the pelvic lean mass was increased in older group (9.1–12 years). However, female children had significantly higher total and pelvic fat masses in all age groups. Moreover, the body composition parameters (lean and fat masses) had positive significant correlations with BMI. These results were supported by Chen *et al.* [35], who did a meta-analysis study on six prospective research studies, including patients with age ranged between 5 and 18 years, and found that increased risk of asthma with obese children, and there was a dose-dependent effect of treatment with BMI; moreover, a sex difference was noticed, with a greater effect in males than females. Boshra *et al.* [20] also confirmed the sex differences. Granell *et al.* [5] reported increased lean mass and fat mass with high-risk asthma in mid-childhood, which persisted to age 15 years in a birth cohort study, and also found a strong positive association between BMI and asthma in those children. Jensen *et al.* [14] assessed the association between lean mass in obese Australia children aged 8–17 years who had asthma by DEXA with lung function and reported that lean mass could be an important parameter than fat mass concerning the respiratory function.

Moreover, other studies on obesity with respiratory disorders reported that fat distribution plays a role, as increased amount of fat mass impaired pulmonary function [29]. They suggested that children controlled by long-term therapy of asthma had accumulated more adipose tissue on the trunk with decreased respiratory functions [33,34].

In the current study, regarding the duration of therapy effect on the body composition, there was a significant increase in total and chest lean masses in male asthmatic children who received short-term ICS compared with a healthy group in the age group 6.1–9 years. Other than that, an insignificant difference could be detected with other parameters in the different age group. Consistent results were found in a previous study which concluded that short-term treatment with ICS does not provoke growth alteration and fat accumulation [35].

Many theories could explain the association between obesity and asthma by an inflammatory process, as adipocytes are a source of pro-inflammatory cytokines [36], and they may promote the immune system activity through adipokine effects [37]. Moreover, a specific phenotype was detected in children with severe asthma [5]. Although, the corticosteroids used in the management of asthma had anabolic action on protein metabolism by increasing synthesis and inhibition of breakdown, causing muscle growth.On the contrary, most of the studies have focused on the inflammatory mechanism of obesity, as fat mass could induce asthma development. We found that both higher lean and fat masses were associated with asthma, especially controlled by long-term corticosteroid. Also changes of the body composition influences asthma, and these results could be explained by Sood *et al.* [13], who reported lean mass in females, particularly in the trunk, which was a good predictor of asthma rather than fat mass, and they suggested the presence of ectopic fat in muscle, which caused inflammatory mediators release. Scott *et al.* [10] reported an association between high lean mass and neutrophilic airway inflammation in asthmatic obese females, although the response to corticosteroids may be poor in association with airway inflammation caused by neutrophil-predominant [38]. Finally, the increased total and pelvic fat masses in females could be explained by physiologically fat distribution on their buttocks and hips (gynoid shape) [13].

In conclusion, accurate assessment of body composition by DEXA allows effective evaluation of total and regional parameters, as well its relationship to the therapeutic duration. The total lean and chest lean masses are increased in asthmatic children controlled by long-term ICS in both sexes.

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Conflicts of interest
There are no conflicts of interest.

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