· Advances in Medical Sciences · Vol. 58(2) · 2013 · pp 331-337 · DOI: 10.2478/ams-2013-0013

How to estimate overweight in pubescent asthmatics?

Varekova R[1], Vareka I[2,3,]*

1 Department of Natural Sciences in Kinanthropology, Faculty of Physical Culture, Palacky University, Olomouc, Czech Republic
2 Department of Rehabilitation, University Hospital, Hradec Kralove, Czech Republic
3 Department of Physiotherapy, Faculty of Physical Culture, Palacky University, Olomouc, Czech Republic

* CORRESPONDING AUTHOR:
Department of Rehabilitation
University Hospital Hradec Kralove
Nezvalova 956
500 36 Hradec Kralove, Czech Republic
Tel.: +420 775 334 911
Fax: +420 495 837 408
email: ivanvareka@seznam.cz (Ivan Vareka)

Received: 03.12.2012
Accepted: 09.05.2013
Advances in Medical Sciences
Vol. 58(2) 2013 · pp 331-337
DOI: 10.2478/ams-2013-0013

ABSTRACT

Purpose: The purpose of our research was to compare the body mass index (BMI) and selected anthropometric parameters in asthmatic and non-asthmatic pubescents.
Material and Methods: The study group consisted of 64 asthmatic boys and 45 girls; the control group consisted of 68 non-asthmatic boys and 48 non-asthmatic girls. All the children were 12-14 years old.
We measured anthropometric parameters by a standardized method and the percentage of fat using the simple 2-site skinfold method. Additionally, we calculated the percentage of body composition (Matiegka) and the components of somatotype (Heath-Carter). Statistical significance was estimated at the level of $p<0.05$ by ANOVA test.
Results: The asthmatic boys were significantly shorter than the non-asthmatic ($p=0.015$), however, we did not find any significant differences in weight and/or BMI in boys nor girls. The asthmatic boys had significantly higher fat mass % than the non-asthmatic ones ($p<0.001$). Moreover, they had significantly lower muscle mass % ($p<0.001$) as well as the bone mass % ($p<0.001$). The asthmatic girls had higher fat mass % than the non-asthmatic ones ($p=0.028$) and lower muscle mass % ($p<0.001$). The simple 2-site skinfold method also showed higher fat % in the asthmatic boys ($p<0.001$) but not in the girls. Examining the Heath-Carter somatotype components, the higher endomorphy was the only significant difference in asthmatic boys ($p<0.001$) and near significant in asthmatic girls ($p=0.053$).
Conclusion: Examination of the BMI alone is not sufficient in asthmatic children because of their high percentage of fat. That is why additionally testing fat % is recommended.

Key words: Anthropometry, asthma, body composition, obesity, overweight, somatotype

INTRODUCTION

The increasing interest in asthma and its etiology reflects its rise, both in developed and developing countries. The prevalence of bronchial asthma in the Czech Republic is estimated to involve 800,000 people (8%), including 350,000 individuals who are not aware of it [1]. Moreover, the prevalence of asthma in children is estimated to be 10-15%, contrary to the 2-3% rate reported in the late 1990s [2]. The incidence of obesity or overweight in adults and children has increased as well [3].

The coincidence of bronchial asthma and obesity or higher body fat percentage has been repeatedly described and the literature dealing with it is abundant. The first reports of association of asthma and obesity emerged in the 1980s [4,5] and the number of these studies rose exponentially until the late 1990s. The detailed summary of the problem has been completed in many meta-analyses [6,7].

The mechanism of the coincidence has been widely discussed. Recent opinions have stressed obesity´s primacy. Enfield et al. [8], explained the coincidence of obesity and asthma bronchiale and/or diabetes mellitus type II as a combination of mechanical and inflammatory effects of obesity. Nevertheless, Glazebrook et al. [9] stated that asthma is a barrier to children's physical activity, which indicates a possible reverse effect of asthma on overweight/obesity. Other factors also contribute to the occurrence of asthma, e.g. Leadbitter et al. [10] found a relationship between fetal growth and the development of asthma and atopy in childhood. Delgado et al. [11] explained the coincidence of asthma bronchiale and obesity as a result of various effects of higher fat mass percentage and/or volume, e.g. reduced pulmonary compliance, lung volumes, diameter of peripheral respiratory airways and the lungs´ blood volume, as well as the ventilation-perfusion relationship. They pointed out that the increase in the normal functioning of adipose tissue in the obese leads to a systemic proinflammatory state, which produces a rise in the serum concentrations of several cytokines, the soluble fractions of their receptors, and chemokines (adipokines), e.g. IL-6, IL-10, tumor necrosis factor-α, transforming growth factors-ß1, C-reactive protein, leptin, and adiponectin. They added that the specific regions of the human genome related to both asthma and obesity have been identified. Gruchala-Niedoszytko et al. [12] summarized results of various studies on animal models as well as studies on asthmatic patients with the following conclusions: 1) the associations between obesity and asthma can be not only causal but also accidental, 2) the levels of inflammation markers in obese asthmatics are related to the parameters of obesity, 3) asthma in obese subjects can differ from the obvious phenotype of this disease and their response to standard medication is reduced. Nevertheless, asthma and obesity can have another unknown common cause [11].

The diagnosis of obesity/overweight and/or body fat percentage can be performed at various levels of complexity. The body mass index (BMI) is a common clinical parameter of overweight because of time saving and its simplicity, nevertheless it should be interpreted with caution. On the other hand, the manual anthropometric measurement of body parameters, including skinfolds, and the subsequent calculation of standardized indexes and formulas is a very sophisticated method. Body composition [13] can be estimated too, however, all these methods are time-consuming and require an experienced examiner. The computerized impedance method seems to be a good compromise, despite that there have been some critical opinions [14].

The purpose of our research was to compare some known non-instrumental methods of overweight measurement, focusing on asthmatic pubescents´.

MATERIAL AND METHODS

Sample

The study group consisted of 64 asthmatic boys (12–14 years old, mean=13.08±0.78) and 45 girls (12–14 years old, mean=13.11±0.78), approx. seventy percent of them used the inhaling corticosteroids. The control group consisted of 68 non-asthmatic boys (12–14 years old, mean=12.96±0.89) and 48 non-asthmatic girls (12–14 years old, mean=13.04±0.8). Their parents signed the consent forms. The asthma´s severity covered a full range from intermittent to severe and persistent. The diagnosis was stated by physicians specialized in allergology, who recommended the spa-therapy too.

Data Collection

The data for the asthmatic children were collected at the Luhacovice Spa (Czech Republic), whereas the data for the non-asthmatic children were collected in elementary schools in Olomouc (Czech Republic).

The anthropometric parameters (11 length and height parameters, 11 width parameters, 13 circumference parameters and the thickness of 14 skinfolds) were measured by the standardized method of Martin and Saler [15]; the bilateral parameters were measured on the right side. The percentage of body composition (Matiegka) [16,17] and the components of somatotype (Heath-Carter) [13] were calculated in Excel, using the formulas acquired from Blaha and Vignerova [16] and Carter [13]. The original Matiegka´s method [17] estimates the components´ mass in grams. We converted the mass to percentages, which enabled us to compare various groups. Moreover, the simple method of fat % based on 2 skinfold calliper measurements (*Tab. 1*) was used to compare the result with the above-mentioned standardized, although complicated methods.

Data Analysis

The results of the Kolmogorov-Smirnov test were non-significant in all the groups and parameters (*Tab. 2* and *Tab. 3*) so the data were tested by means of the ANOVA post hoc LSD test. Statistical significance was estimated at the level of $p<.05$. Software Statistica, Cz 6 (StatSoft, 2001) was employed [18].

RESULTS

The body height was significantly lower in asthmatic boys (*Tab. 2*) than in the non-asthmatic ones (mean=157.7±9.67 and 161.1±11.56 cm, respectively; p=0.015), but the differences in weight and/or BMI were not significant. We did not find any differences in these parameters in girls.

The differences in the body composition parameters (according to Matiegka's method [16]) were significant in boys as well as in girls (*Tab. 3*). The asthmatic boys had

***Table 1.* Formulas of body fat % based on two skinfolds [16].**

Boys % fat = 0.735 x (triceps skinfold + subscapularis skinfold) + 1
Girls % fat = 0.61 x (triceps skinfold + subscapularis skinfold) + 5.1

Table 2. **Basic anthropometric parameters.**

	group	mean	Kolmogorov-Smirnov test	ANOVA (Fisher´s LSD post hoc test) significance			
				asthmatic boys	non-asthmatic boys	asthmatic girls	non-asthmatic girls
age	asthmatic boys	13.1±0.78	0.224		0.392	0.836	0.816
	non-asthmatic boys	13±0.89	0.271	0.392		0.324	0.579
	asthmatic girls	13.1±0.78	0.230	0.836	0.324		0.683
	non-asthmatic girls	13±0.8	0.218	0.816	0.579	0.683	
height	asthmatic boys	157.7±9.67	0.810		0.015	0.936	0.218
	non-asthmatic boys	161.7±11.46	0.057	0.015		0.033	0.310
	asthmatic girls	157.9±7.65	0.115	0.936	0.033		0.290
	non-asthmatic girls	159.9±6.2	0.102	0.218	0.310	0.290	
weight	asthmatic boys	48.7±12.15	0.101		0.343	0.512	0.243
	non-asthmatic boys	50.5±12.24	0.080	0.343		0.844	0.760
	asthmatic girls	50.1±9.69	0.100	0.512	0.844		0.645
	non-asthmatic girls	51.2±9.58	0.158	0.243	0.760	0.645	
BMI	asthmatic boys	19.3±3.24	0.117		0.663	0.268	0.286
	non-asthmatic boys	19.1±3.02	0.155	0.663		0.130	0.139
	asthmatic girls	20±3.11	0.157	0.268	0.130		0.955
	non-asthmatic girls	20±3.5	0.160	0.286	0.139	0.955	

significantly higher fat mass % than the non-asthmatic ones (mean=24.6±11.08 and 17.9±8.37 %, respectively; p<0.001). Moreover, they had significantly lower muscle mass % (mean=38±4.85 and 42.7±4.81 %, respectively; p<0.001) as well as bone mass % (mean=18.8±2.44 and 20.3±2.59 %, respectively; p<0.001). The asthmatic girls had higher fat mass % than the non-asthmatic ones (mean=28.8±7.81 and 24.7±7.82 %, respectively; p=0.028) and lower muscle mass % (mean=35.2±5.21 and 39.8±5.09 %, respectively; p<0.001). Furthermore, *Tab. 3* shows significant differences between the asthmatic boys and girls as compared to the non-asthmatic ones in the cases of all the three parameters. The boys had higher muscle and bone mass % and lower fat mass % than the girls.

The simple 2-site skinfold method also showed higher fat % in the asthmatic boys (mean 20.5±11.5 and 13.7±7 %, respectively, p<0.001), but not in girls. When comparing it to the reference values of Blaha and Vignerova [16], our non-asthmatic boys belong in the 50th percentile and the asthmatic ones are near the 90th percentile. Nevertheless, both the groups of the non-asthmatic and asthmatic girls are near the 75th percentile. So our non-asthmatic girls were above the average fat % of 13 years old Czech girls. Therefore, we did not find the difference between the girls' groups.

Examining the Heath-Carter somatotype components [13], the difference in endomorphy was the only significant difference between asthmatic and non-asthmatic boys (mean=4.1±2.2 and 2.7±1.8, respectively; p<0.001). In girls the difference in endomorphy was only near-significant (mean=4.6±1.7 and 3.8±1.7, respectively; p=0.053).

DISCUSSION

Asthma and puberty

Balfour-Lynn [19] prospectively examined thirty-eight chronic, perennially asthmatic children to clarify the relationship between clinical asthma and puberty, examining them every six months for 9 years (the mean was 8.9 years). The rate of improvement was appreciably greater during puberty. The author speculated that the improvement could be associated with immunological and hormonal changes. When the illness improved before any sign of puberty had developed, the child could be confidently predicted to 'grow out' of this disease. However, if no improvement was seen by the onset of puberty, a much more vigilant prognosis is needed. Guerra et al. [20] related the persistence of asthma after the onset of the puberty to the beta2-adrenoceptor polymorphisms at the codons - 16 in the boys, but not in the girls. Varraso et al. [21] found that the above-mentioned relationship between the BMI and asthma severity in women was stronger in women with early menarche (<11 years). Balfour-Lynn [19] found the tendency of the delay in the onset of puberty in the asthmatic boys and girls, but independent of the asthma severity. Moreover, once puberty began, these children attained their predicted adult height. The delayed onset of puberty in asthmatics is also mentioned by Delemarre et al. [22]. We found a lower body height in asthmatic boys aged 12-14 years (see below), which could be an indication of a delayed onset of puberty.

Table 3. **Body composition [16] and somatotype components [13].**

	group	mean	Kolmogorov-Smirnov test	ANOVA (Fisher´s LSD post hoc test) significance			
				asthmatic boys	non-asthmatic boys	asthmatic girls	non-asthmatic girls
bone mass %	asthmatic boys	18.8±2.44	0.051		<0.001	<0.001	<0.001
	non-asthmatic boys	20.3±2.59	0.093	<0.001		<0.001	<0.001
	asthmatic girls	16±1.67	0.086	<0.001	<0.001		0.182
	non-asthmatic girls	16.7±2.42	0.084	<0.001	<0.001	0.182	
fat mass %	asthmatic boys	24.6±11.08	0.101		<0.001	0.017	0.966
	non-asthmatic boys	17.9±8.37	0.182	<0.001		<0.001	<0.001
	asthmatic girls	28.8±7.81	0.126	0.017	<0.001		0.028
	non-asthmatic girls	24.7±7.82	0.086	0.966	<0.001	0.028	
muscle mass %	asthmatic boys	38±4.85	0.056		<0.001	0.003	0.048
	non-asthmatic boys	42.6±4.81	0.070	<0.001		<0.001	0.003
	asthmatic girls	35.2±5.21	0.124	0.003	<0.001		<0.001
	non-asthmatic girls	39.8±5.09	0.095	0.048	0.003	<0.001	
endomorphy	asthmatic boys	4.1±2.2	0.140		<0.001	0.170	0.479
	non-asthmatic boys	2.7±1.8	0.190	<0.001		<0.001	0.001
	asthmatic girls	4.6±1.7	0.081	0.170	<0.001		0.053
	non-asthmatic girls	3.8±1.7	0.114	0.479	0.001	0.053	
mesomorphy	asthmatic boys	4±1.4	0.054		0.325	0.030	0.054
	non-asthmatic boys	4.2±1.7	0.095	0.325		0.002	0.004
	asthmatic girls	3.4±1.3	0.074	0.030	0.002		0.789
	non-asthmatic girls	3.5±1.2	0.083	0.054	0.004	0.789	
ectomorphy	asthmatic boys	3.3±1.6	0.054		0.161	0.197	0.793
	non-asthmatic boys	3.7±1.4	0.139	0.161		0.010	0.119
	asthmatic girls	3±1.6	0.103	0.197	0.010		0.332
	non-asthmatic girls	3.2±1.4	0.083	0.793	0.119	0.332	
fat % from 2 skinfolds	asthmatic boys	20.5±11.5	0.161		<0.001	0.267	0.578
	non-asthmatic boys	13.7±7	0.070	<0.001		<0.001	<0.001
	asthmatic girls	22.3±7.6	0.068	0.267	<0.001		0.121
	non-asthmatic girls	19.6±6.8	0.076	0.578	<0.001	0.121	

The Height, Weight and BMI

We did not find any significant difference in the weight and BMI between the asthmatics and the non-asthmatics in their weight and BMI, but there was a significant difference in the height between the asthmatic and non-asthmatic boys.

Gulliver et al. [23] pointed out several longitudinal studies, which established a small decrement in growth velocity (approximately 1–2 cm) during the first year of treatment by means of inhaled corticosteroids. However, the budesonide medication in children, taken for up to 10 years, did not change their target height in adulthood [23]. Chen et al. [24] found the association between asthma bronchiale and higher BMI in 22-65 year old female patients, although not in male ones, in his longitudinal study. Likewise, Romieu et al. [25] found that a high BMI is significantly related to the risk of asthma incidence in women aged 40–65 years. We did not find significant differences in BMI between the asthmatic and non-asthmatic children, neither in the girls nor the boys. The overall validity of BMI use in children is disputed among researchers, although it is recommended for clinical use and screening of obesity in children [26] but not for research. However, concerning us, Chinn et al. [27] did not find any coincidence of asthma and BMI in 8-9 year old children. El-Baz et al. [28] found a significantly higher BMI in children with an obstruction of the small airways and other asthma symptoms, but apparently the difference in age was too big (median 12.8 and 10.8, respectively), although non-significant (p<0.07), between the study group and the control group. Tantisira et al. [29] did not find any association of BMI with asthma symptoms and/or atopy in the 1,041 asthmatic children aged 5–12 years, but the association of the decreased FEV1/FVC ratio with an increase in BMI by 5 units was confirmed.

Joshi et al. [30] used linear regression analysis, using age, height and weight as independent variables and peak expiratory flow rate as the dependent variable in 110 Indian boys (6–15 years of age) engaged in carpet weaving factories. The peak expiratory flow rate values of all carpet weaving children were significantly lower (p<0.05) than the controls, except for the 6–7 year old group. Their height and weight were also lower (p<0.05) [30], in contrast to our results. Although we did not know the fat mass and its distribution in the Joshi carpet weaving boys, we assumed, based on their race, working lifestyle and the energy intake common in India, that they were not overweight. However, we could presume significant differences in the lifestyle and usual energy intake between Indian working children and our group of children from Central Europe.

Body Composition and Somatotype

We used a standard manual anthropometric examination, followed by the computation of other parameters. The advantage of our selected procedure is the knowledge of every step, including the equations used. This is in contrast to the new computerised devices and software, which in addition give mutually very different results, as described by Kinkorova et al. [14].

Although the original Matiegka´s method [17] underestimates the mass of muscle and fat and overestimates the mass of bone [31], we can expect the deviation to be similar in all the groups. The differences in body composition, according to the Matiegka´s method [16,17], between the asthmatic and non-asthmatic children, were frequent. The asthmatic boys and girls had a significantly higher percentage of fat mass and a significantly lower percentage of bone mass as well as muscle mass than the non-asthmatic ones. The simple 2-site skinfold method also showed a higher fat percentage in the asthmatic boys, but not in the girls. However, in the original Matiegka´s method [17], the "fat mass" is the mass of the skin and the subcutaneous fat; the visceral fat is not included.

The difference in the somatotype parameters was not very common in its occurrence. Endomorphy was the only one that was significantly higher in the asthmatic boys and near-significant in the asthmatic girls. More evident differences seen in the comparison of boys with girls are perhaps linked to the fact that our group of non-asthmatic girls is too fat, compared to the reference values for Czech children in general (*Tab. 4*). A different time of their start of puberty and related hormonal changes in the boys and girls are likely to be other influential factor. Moreover, our groups of asthmatic and non-asthmatic girls were not large.

Table 4. **Percentiles of fat % based on 2-skinfold method [16].**

	50^{th} percentile	75^{th} percentile	90^{th} percentile
boys (13 years)	13.05	16.69	22.20
girls (13 years)	18.24	21.69	26.61

The reduced (striated) muscle mass in asthmatics is possibly the effect of hypo-activity as the result of or the parallel symptom of obesity/overweight and/or the apprehension of exercise-induced asthmatic paroxysm. Moreover, hyperprotective parents are an important factor in the children's lifestyle. Bowyer et al. [32] evaluated muscle weakness in the prednisone-treated asthmatic. They found the hip flexors strength to be more than two standard deviations below the mean of age and sex-matched control subjects by means of Cybex testing, but found no biochemical signs of steroid induced myopathy. Nevertheless, no study of striated muscle mass percentage is available in asthmatic adults nor children. We can only deduce similar effects of asthma and chronic obstructive pulmonary disease (COPD) on the striated muscles. The effect of COPD in adults was repeatedly discussed [33], however, not in children, since COPD in children is rare.

Reduced bone mass in asthmatics is likely due to the above-mentioned hypo-activity and/or the repeatedly discussed probable effect of the inhaled corticosteroids on the bone mass. This question has not been resolved yet. Hassan et al. [34] did not find any effect of the long-term inhaled corticosteroids on the anthropometric measurements in 60 children (40 boys and 23 girls, aged 3–10 years). Jones et al. [35] measured bone densitometry and body composition by the dual-energy x-ray absorptiometry in 330 pre-pubertal children, 110 of them diagnosed with asthma. They did not find any association of asthma with deficit in bone mass, but the application of inhaled corticosteroids in the last year was linked to deficits in bone mass.

CONCLUSIONS

Although we failed to demonstrate significant differences in BMI between asthmatics and non-asthmatics, we found significant differences in body composition. Increased percentages of fat mass and decreased percentage of muscle and bone mass were significant both in the asthmatic boys and girls. Additionally, the higher endomorphic component of somatotype in the asthmatics was an indication of a higher fat component. We can conclude that a mere examination of BMI is not sufficient in asthmatic children because of hidden overweight. Consequently, the BMI calculation should be used in conjunction with other measures, at least with fat percentage measurement methods. Examination according to Matiegka's method [16,17] can be recommended for research, however it is complicated and time consuming. Therefore, the simple method of fat % calculated from 2-site skinfold measurements is appropriate for a rough clinical examination and/or the instrumental measuring of tissue impedance, despite its lower accuracy.

REFERENCES

1. Kašák V. Astma - pověry, mýty, fakta v roce 2011 [Asthma - superstitions, myths and facts in 2011]. Alergie. 2011;13(2):94-100. Czech.
2. Turzíková J. Novinky v přístupu k dětskému pacientovi s alergickou rýmou a asthma bronchiale [New approach to children with allergic rhinitis and asthma bronchiale]. Pediatr praxi. 2012;13(2):88-94. Czech.
3. Braunerová R, Hainer V. Obezita – diagnostika a léčba v praxi [Obesity – diagnostics and treatment in the general practice]. Med Pro Praxi. 2010;7(1):19–22. Czech.
4. Seidell JC, de Groot LC, van Sonsbeek JL, Deurenberg P, Hautvast JG. Associations of moderate and severe overweight with self-reported illness and medical care in Dutch adults. Am J Public Health. 1986 Mar;76(3):264-9.
5. Negri E, Pagano R, Decarli A, La Vecchia C. Body weight and the prevalence of chronic diseases. J Epidemiol Community Health. 1988 Mar;42(1):24-9.
6. Shore SA, Johnston RA. Obesity and asthma. Pharmacol Ther. 2006 Apr;110(1):83-102.
7. Beuther DA, Sutherland ER. Overweight, obesity and incident asthma: a meta-analysis of prospective epidemiologic studies. Am J Respir Crit Care Med. 2007 Apr; 175(7):661-6.
8. Enfield K, Shim M, Sharma G. Asthma, obesity and type 2 diabetes: mechanisms, management and prevention. Diabetes Voice. 2009 Jun;54(2):30-3.
9. Glazebrook C, McPherson A, McDonnald IA, Swift JA, Ramsay C, Newbould R, et al. Asthma as barrier to children's physical activity: implications for body mass index and mental health. Pediatrics. 2006 Dec;118(6):2443-9.
10. Leadbitter P, Pearce N, Cheng S, Sears MR, Holdaway MD, Flannery EM, et al. Relationship between fetal growth and the development of asthma and atopy in childhood. Thorax. 1999 Oct;54(10):905-10.
11. Delgado J, Barranco P, Quirce, S. Obesity and asthma. J Investig Allergol Clin Immunol. 2008;18(6):420-5.
12. Gruchała-Niedoszytko M, Małgorzewicz S, Niedoszytko M, Gnacińska M, Jassem E. The influence of obesity on inflammation and clinical symptoms in asthma. Adv Med Sci. 2013;58(1):15-21.
13. Carter JEL. The Heath-Carter anthropometric somatotype. Instruction manual. San Diego: San Diego State University; 2002. 26 p.
14. Kinkorova I, Heller J, Moulis J. Possibilities for the use of selected methods for the determination of body composition in children in their adolescent stage. Acta Univ Palacki Olomuc Gymn. 2009 Mar; 39(1):49-58.
15. Martin R, Saller K. Lehrbuch der Anthropologie: in systematischer Darstellung mit besonderer Berücksichtigung der anthropologischen Methoden. 3rd ed. Vol. 2. Stuttgart: G. Fischer Verlag; 1959. p. 663-1574. German.
16. Blaha P, Vignerova J. Investigation of the growth of Czech children and adolescents: Normal, underweight, overweight. Prague: National Institute of Public Health; 2002. 130 p.17.
17. Matiegka, J. Testing of physical efficiency. Am J Phys Anthropol. 1921;4(3):223-330.
18. StatSoft, Inc. STATISTICA Cz (Software system for data analysis). Version 6.0. Praha: StatSoft, Inc.; 2001.
19. Balfour-Lynn L. Growth and childhood asthma. Arch Dis Child. 1986 Nov;61(11):1049-55.
20. Guerra S, Graves PE, Morgan WJ, Sherrill DL, Holberg CJ, Wright AL, et al. Relation of beta2-adrenoceptor polymorphisms at codons 16 and 27 to persistence of asthma symptoms after the onset of puberty. Chest. 2005 Aug;128(2):609-17.
21. Varraso R, Siroux V, Maccario J, Pin I, Kauffmann F, Epidemiological Study on the Genetics and Environment of Asthma. Asthma severity is associated with body mass index and early menarche in women. Am J Respir Crit Care Med. 2005 Feb;171(4):334-9.
22. Delemarre EM, Felius B, Delemarre-van de Waal HA. Inducing puberty. Eur J Endocrinol. 2008 Dec;159 Suppl 1:S9-15.
23. Gulliver T, Morton R, Eid N. Inhaled corticosteroids in children with asthma: pharmacologic determinants of safety and efficacy and other clinical considerations. Paediatr Drugs. 2007 May;9(3):185-94.
24. Chen Y, Dales R, Tang M, Krewski D. Obesity may increase the incidence of asthma in women but not in men: longitudinal observations from the Canadian National Population Health Surveys. Am J Epidemiol. 2002 Feb;155(3):191-7.
25. Romieu I, Avenel V, Leynaert B, Kauffmann F, Clavel-Chapelon F. Body mass index, change in body silhouette, and risk of asthma in the E3N cohort study. Am J Epidemiol. 2003 Jul;158(2):165-74.
26. Dietz WH, Bellizzi MC. Introduction: the use of body mass index to assess obesity in children. Am J Clin Nutr. 1999 Jul;70(1):123S-5S.
27. Chinn S, Rona RJ. Can the increase of body mass index explain the rising trend in asthma in children? Thorax. 2001 Nov;56(11):845-50.
28. El-Baz FM, Abdelaziz EA, Abdelaziz AA, Kamel TB, Fahmy A. Impact of obesity and body fat distribution on pulmonary function of Egyptian children. Egyp J Bronch. 2009 Jun;3(1):49-58.

29. Tantisira KG, Litonjua, AA, Weiss ST, Fuhlbrigge AL, Childhood Asthma Management Program Research Group. Association of body mass with pulmonary function in the Childhood Asthma Management Program (CAMP). Thorax. 2003 Dec;58(12):1036–41.

30. Joshi SK, Sharma P, Sharma U, Sitaraman S, Pathak SS. Peak expiratory flow rate of carpet weaving children. Indian Pediatrics. 1996 Feb;33(2):105-8.

31. Shepard RJ. Cambridge studies in biological anthropology. Vol. 6, Body composition in biological anthropology. Cambridge: Cambridge University Press; 1991. 345 p.

32. Bowyer SL, LaMothe MP, Hollister JR. Steroid myopathy: incidence and detection in a population with asthma. J Allergy Clin Immunol. 1985 Aug;76(2 Pt 1):234-42.

33. Casaburi R. Skeletal muscle function in COPD. Chest. 2000 May;117(5 Suppl 1):267S-71S.

34. Hassan NE, Abd El-moniem MM, Shaalan A. Long term inhaled corticosteroids in childhood asthma: Impact on growth and adrenocortical function. Report and Opinion. 2010;2(3):23-35.

35. Jones G, Ponsonby AL, Smith BJ, Carmichael A. Asthma, inhaled corticosteroid use, and bone mass in prepubertal children. J Asthma. 2000;37(7):603-11.