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Relationship of asthma control test scores with pulmonary function tests, quality of life and adiposity in asthmatic children

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Abstract. – OBJECTIVE: This study aimed at assessing asthma control test (ACT score), quality of life (QOL), and pulmonary functions in asthmatic children, and to see the correlations between ACT score, QOL, and pulmonary functions.

PATIENTS AND METHODS: This cross-sectional study was conducted at the departments of pediatrics and physiology, College of Medicine, King Saud University Medical City (KSUMC), Riyadh, Saudi Arabia. A total of 109 (53 asthmatics and 56 controls) children (aged 6 to 13 years) of both genders were studied. All subjects underwent clinical evaluation, 36-Item Short Form Survey (SF-36) for QOL, Spirometry, and cognitive assessment through mini mental state examination (MMSE).

RESULTS: QOL showed significantly lower scores in asthmatic compared to non-asthmatic children. The higher social functioning [SF] (p=0.0012) and less role limitation due to physical health [RLPH] (non-asthmatic patients had had higher physical functioning [PF] (p=0.0001), less energy/fatigue [EF] (p=0.0008=0.0068). On the opposite side, no significant difference was found regarding role limitations due to emotional problems [RLEP] (p=0.0644) and Emotional well-being [EW] (p=0.0758) between the two groups. A significant positive correlation was seen between QOL items and ACT score in PF (r=.535, p<0.01), less RLPH (r=.593, p<0.01), less FE (r=.379, p<0.01), higher EW (r=.310, p<0.05), and higher SF (r=.495, p<0.01). No significant correlation was found between body mass index (BMI) and lung functions in children with asthma. Interestingly, a positive correlation was found in asthmatic children between BMI and MMSE scores (r=.298, p=0.030).

CONCLUSIONS: Our study concluded that QOL in asthmatic patients was significantly lower than healthy subjects in terms of patient's physical functioning and social life. However, the emotional aspects of QOL were not significantly affected in asthmatic children.

Key Words:
Asthma, Children, Asthma control test score, Quality of life, Pulmonary function tests.

Introduction

Asthma is a condition with inflammation of the air passages in the lungs in which sensitivity of the nerve endings in the airways is increased. During an acute attack of exacerbation, the airways lumen narrows down and increases the work of breathing. Asthma can affect all age groups but often begins in early childhood. It is among the top of the chronic diseases affecting children worldwide[1]. According to the global estimate of asthma burden in 2014, there were about 334 million people suffering from asthma. Asthma is still a common cause of death in many countries[2,3]. It is estimated that asthma accounts for about 1 in every 250 deaths worldwide[2]. On the other hand, the financial burden of asthma is substantial and about $56 billion was the expense of asthma in the US in 2009. In the Kingdom of Saudi Arabia, it is on the trend of diseases affecting more than two million Saudis[4]. Many research studies favor a link between a high body mass index (BMI) and obesity in asthmatics both in adult and pediatric populations. Obesity is defined as an abnormal or excessive fat accumulation that presents a greater risk to health. It is characterized by a systemic inflammatory state caused, at least, in part by different adipokines secreted by the adipose tissue[5]. According to a WHO report in 2014 there were more than 1.9 billion adults who were overweight, and about 41 million children under the

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age of 5 were overweight or obese. While in the eastern Mediterranean region from 1980 to 2013 the largest increase in obesity rates was in Egypt, Saudi Arabia, Oman, and Bahrain for both men and women[6]. The incidence of obesity in adults, adolescents, and children is increasing at a rapid rate. Therefore, the comorbidities associated with obesity are also significantly increasing and include diabetes mellitus, hypertension, heart disease, stroke, cancer, and abnormalities in the endocrine and pulmonary systems. Prevalence of obesity has increased by 27.5% in adults and 47.1% in children between 1980 and 2013 worldwide. The population of obese people has risen from 857 million to 2.1 billion between 1980 and 2013 in both developing and developed countries.

Obesity can be assessed by BMI and more accurately by body composition. Although, BMI is a simple tool to assess overweight and obesity in adults and children, but it is a poor indicator of adiposity and has a lot of limitations to determine the true estimate of adiposity. Bio-impedance analysis is a simple and more accurate method to assess adiposity. There are few data in literature showing the relationship of adiposity with control of asthma and its severity scores. To the best of our knowledge, no studies have examined an integrated relationship of body composition with pulmonary function tests (PFTs), quality of life (QOL), and asthma control test (ACT score) in asthmatic children. Therefore, we aimed to assess body fat percentage, pulmonary functions, QOL, and ACT score in asthmatic children. Moreover, we aimed to evaluate the correlation between pulmonary functions, QOL, ACT score, and adiposity in children suffering from asthma.

Patients and Methods

This comparative cross-sectional study was carried out at the Departments of Physiology and Pediatrics, College of Medicine, King Saud University Medical City (KSUMC), Riyadh, Saudi Arabia from February 2017 to June 2017. A total of 109 children (53 asthmatics and 56 controls) with age range from 6 to 13 years of both genders were studied. The study population included 37 males and 19 females in the control group, while 37 males and 16 females in the asthmatic group. The subjects were recruited with the convenience sampling technique. For QOL assessment we used the Pediatric Asthma Quality of Life Questionnaire (PQOL)[7], which was already translated and validated in the Arabic language by RAND health (36-Item Short Form Survey).

The Ethical approval was obtained for this study under the project number MB3 from the Institutional Review Board (IRB) Committee of the College of Medicine (CMED) for research projects. This study was performed according to the principles of Helsinki Declaration.

Recruited patients were already diagnosed cases of asthma according to the American thoracic society guidelines with a history of at least one-year duration and control subjects were age matched healthy children without any respiratory problems. We excluded all subjects with chronic disease, for example diabetes mellitus and hypertension, congenital anomalies, allergic rhinitis, chronic obstructive pulmonary disease, bronchiectasis, emphysema, interstitial lung diseases, and tumors. We obtained informed consent from parents or relatives of all subjects. Detailed history was taken, and ACT score was calculated using a validated Arabic version interview questionnaire[7]. We assessed QOL using PQOL inventory which included the domains of the energy/fatigue (EF), physical functioning (PF), role limitations due to emotional problems (RLEP), role limitations due to physical health (RLPH), emotional well-being (EW), and social functioning (SF)[8]. The subjects underwent height measurement. Then, body compositions assessment was analyzed by bioelectrical impedance analysis (BIA) using commercially available Body Composition Analyzer (TANITA Corporation, Tokyo, Japan, Type BC-418 MA). Spirometry and respiratory muscle strength recordings were obtained to evaluate the pulmonary functions. We measured them based on the American thoracic society guidelines[9].

We used spirodoc (Medical International Research, MIR, Rome, Italy) for Spirometry and Micro Respiratory Pressure meter (MicroRPM, Lewiston, ME, USA) for respiratory muscle strength measurement[10]. Spirometer recorded forced vital capacity (FVC), forced expiratory volume in first second (FEV_1), forced vital capacity (FVC), and forced expiratory volume in the first second ratio (FEV_1/FVC), peak expiratory flow (PEF), forced expiratory flow 25 to 75% (FEF 25%-75%), and forced expiratory time (FET). We repeated the tests three times and the best record was included in the final results[11]. Moreover, we measured the respiratory muscles strength by measuring maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP), which are helpful to measure the weakness of the respiratory muscles and to determine its severity[12,13].

Statistical Analysis

Statistical analysis was performed using the Statistical Package for Social Science version (SPSS 21.0; IBM, Armonk, NY, USA). Numerical data was expressed as mean and standard deviation (SD). The tests applied for Statistical analysis were independent Student's *t*-test for normal distributed data and Mann-Whitney U test for data which was not following normal distribution. Pearson's correlation coefficients and Spearman's rank order correlations were used where required. *p*-value of <0.05 was considered statistically significant.

Results

Table I shows the comparison of the clinical, demographic characteristics, and PFTs between control and asthmatics. The control subjects had significantly higher height (p=0.0045), weight (p=0.0082), and BMI (p=0.0338) compared to asthmatic subjects. There was no significant difference between gender distribution (p=0.6794), age (p=0.1036) and body fat % [BF%] (p=0.3941). The average ACT Score in asthmatic patients was 21.3 ranging between 9 and 27 (Table II). About 41 cases (78.84%) had ACT score of >19 which shows good control, while the remaining 11 cases (21.15%) had ACT score <19 demonstrating poor control. Comparison of MMSE and QOL parameters between the control and asthmatic children is shown in Table III. QOL showed significantly lower scores in asthmatic compared to non-asthmatic children. The non-asthmatics had had higher physical functioning [PF] (p=0.0001), less energy/fatigue [EF] (p=0.0008), higher social functioning [SF] (p=0.0012), and less role limitation due to physical health [RLPH] (p=0.0068). On the opposite side, no significant difference was found regarding role limitations due to emotional problems [RLEP] (p=0.0644) and emotional well-being [EW] (p=0.0758) between the two groups.

Table II. Comparison of good and poor ACT score in all asthma patients.

Asthma Control Test Score	
Mean ACT score (range)	21.3 (9-27)
Good control	78.84% (41)
Poor control	21.15% (11)

Tables IV and V express the correlations between QOL, demographic characteristics, body composition analysis, and PFTs in asthmatic children. The results revealed that ACT Score correlated positively with most of QOL items such as PF (r=.535, p<0.01), RLPH (r=.593, p<0.01), EF (r=.379, p<0.01), EW (r=.310, p<0.05), and SF (r=.495, p<0.01)]. We observed that body weight also showed positive correlations with FVC (r=.470, p<0.01), FEV_1 (r=.313, p<0.05), PEF (r=.504, p<0.01), FEF 25%-75% (r=.372, p<0.01), MIP (r=.361, p<0.01) except higher FVC/FEV_1 ratio was correlated negatively (r=-.301, p<0.05). BMI positively correlated with FVC (r=.328, p<0.05), FEV_1 (r=.314, p<0.05), PEF (r=.407, p<0.01), FEF 25%-75% (r=.433, p<0.01), and MIP (r=.410, p<0.01).

Discussion

The present study shows an integrated relationship between body composition Pulmonary function tests (PFTs), Quality of life (QOL), and asthma control test (ACT score) in a group of children suffering from bronchial asthma. We observed significant differences in the QOL scores in different domains like PF, RLPH, SF, EF, and EW. Asthmatic children had lower scores

Table I. Comparison of clinical, demographic characteristics, and PFTs between control and asthmatics.

Variables	Control (n=56)	Asthmatics (n=53)	*p*-value
Gender			
Male 74 (67.89 %)	37 (66%)	37 (69.81 %)	0.6794
Female 35 (32.11 %)	19 (33.9%)	16 (28.84 %)	
Age (years)	9.07 ± 1.42	8.58 ± 1.43	0.1036
Height (meters)	1.35 ± 0.13	1.28 ± 0.14	0.0045
Weight (kg)	36.08 ± 12.92	29.35 ± 13.16	0.0082
Body fat %	21.78 ± 11.15	20.06 ± 9.53	0.3941
Body Mass Index (BMI)	19.34 ± 5.63	17.25 ± 4.42	0.0338

Data are expressed as Mean±SD.

Table III. Comparison of Mini Mental State Examination (MMSE) and QOL parameter scores between control and asthmatic children.

Variables	Control	Asthmatics	*p*-value
Mini Mental State Examination	26.78±2.95	25.35±4.57	0.0522
QOL Scores			
Physical functioning	977.68±78.85	876.42±171.70	0.0001
Role limitations due to physical health	387.50±60.49	332.08±136.96	0.0068
Role limitations due to emotional problems	291.07±34.52	269.81±77.42	0.0644
Energy/fatigue	330.00±60.30	283.77±78.75	0.0008
Emotional well-being	411.79±70.71	384.15±89.56	0.0758
Social functioning	196.43±13.84	180.66±32.93	0.0012

Data are expressed as Mean±SD.

in comparison with non-asthmatics in many domains of QOL. The most significant differences were seen in PF, RLPH, and SF. Similar to our results Furtado et al[14] reported that physical activities were the most restricted activities in asthmatic children. Interestingly we did not observe a significant difference in emotional well-being scores between healthy and asthmatic children. The reason for these results might be better hospital care, free health facilities, combined family system, and cultural practices of special care for sick people in Saudi communities. A similar report supporting this observation[15] showed that increase in number of emergency department visits and timely effective use of reliever medications predicted better emotional quality of life scores not only for asthmatic children but also better physical quality of life scores for parents. Moreover, Padding et al[16] conducted in asthmatic children it has been observed that increase in awareness about the disease and counselling has reduced the emotional burden of participation in asthma research and activities. Regarding MMSE scores asthmatic patients showed lower mean scores with a borderline *p*-value of 0.052, which may be due to better health care and facilities in Saudi Arabia. Another interesting observation was a positive correlation between BMI and MMSE scores in asthmatic children. Moreover, body fat percentage had a significant positive correlation with the MMSE scores. Similar to our results Tikhonoff et al[17] reported that higher BMI and particularly higher body fat mass were positively associated with better performance at the cognitive tasks. On the contrary, Smith et al[18] found that obese children have lower cognitive indices in comparison with children of ideal body weights.

Table IV. Correlation of demographic characteristics and PFTs with QOL parameters.

	PF	RLPH	RLEP	EF	EW	SF	TS
Age	-.005	.059	.197	.072	.286*	.010	.129
Wt	.005	.184	.291*	.018	.200	.176	.193
BF%	.028	-.135	.119	-.018	-.015	-.015	-.017
BMI	.075	.135	.245	.078	.083	.182	.170
ACT score	.535**	.593**	.224	.379**	.310*	.495**	.625**
Cognitive score	-.090	-.063	.215	.133	.059	-.032	-.009
FVC	-.021	-.110	-.104	.225	.492**	.046	.051
FEV_1	.043	-.037	-.059	.119	.083	.026	.016
FVC/FEV_1	.020	-.065	-.197	.089	.075	.001	-.037
PEF	.068	.037	.144	.109	.229	.065	.134
FEF 25%-75%	.145	.120	.131	.262	.245	.111	.205
FET	.053	.182	.153	-.057	.010	.141	.137
MIP	-.056	-.082	.028	.188	.204	-.025	-.003
MEP	-.014	-.313*	-.156	.174	.205	-.159	-.118

Abbreviations: Physical functioning (PF), role limitation due to physical health (RLPH), role limitation due emotional problems (RLEP), energy/fatigue (EF), emotional well-being (EW), social functioning (SF), total score (TS). **Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

Table V. Correlations between demographic characteristics, spirometry parameters, and respiratory muscle strength.

	FVC	FEV_1	FEV_1/ FVC Ratio	PEF	FEF 25%-75%	FET	MIP	MEP
Age	.400**	.263	-.218	.515**	.268	.103	.338*	.264
Weight	.470**	.313*	-.301*	.504**	.372**	.213	.361**	.169
BF%	.248	.210	-.107	.325*	.402**	.037	.302*	.287*
BMI	.328*	.314*	-.194	.407**	.433**	.100	.410**	.233
ACT score	..070	-.106	-.025	.150	.149	.114	.048	-.101
Cognitive score	-.165	-.116	-.219	.268	.110	-.093	.059	.098

Abbreviations: Forced vital capacity (FVC), Forced expiratory volume in first second (FEV_1), Forced vital capacity (FVC) & Forced expiratory volume in first second ratio (FEV_1/FVC), Peak expiratory flow (PEF), Forced expiratory flow 25 to 75% (FEF 25%-75%), Forced expiratory time (FET), Maximum inspiratory pressure (MIP), Maximum expiratory pressure (MEP). **Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

We did not find a significant correlation, in asthmatic children, between ACT score, PFTs, and adiposity indices. Although Karachaliou et al[19] reported that the higher the BMI the more is odds ratio of asthma symptoms to be present. Also, Manion et al[13], concluded that obesity has a major effect on the asthma severity. Gomez-Llorente et al[5], mentioned that obesity is linked significantly to asthma with more severe symptoms, destabilization or lack of asthma control, and worse QOL. On the other hand, we observed that there was a positive correlation between ACT score and QOL items, including PF, RLPH, FE, SF, and EW. Therefore, higher ACT scores, which are indicative of better control of asthma, predict a better QOL for asthmatic children. According to Petsios et al[12] asthma control is the most important factor positively affecting the QOL regardless other factors such as: gender, age, duration of treatment, and socioeconomic status. Ricci et al[8] also demonstrated that asthma control plays a major role in improving different aspects of QOL. Children who had poor asthma control had significantly lower QOL scores. It is also reported that children with asthma have more school absentees than healthy children. Moreover, both undiagnosed and diagnosed asthma had a significant impact on the QOL of both children and their caregivers[20]. In addition, Furtado et al[14] found that children with controlled asthma had higher QOL scores compared to the uncontrolled.

There was a positive correlation between body weight and limitations due to emotional problems. Moreover, age was positively correlated with emotional well-being. The explanation might be that with age there would be more understanding of the disease as well as adaptation to it. Moreover, there was a positive correlation between FVC and emotional wellbeing that may be attributed to good control of asthma. The lack of significant correlations with other parameters of Spirometry with other items of QOL need further studies and exploration. In asthmatic children, ventilatory parameters showed a positive correlation of age with higher FVC, PEF, and MIP which is due to rapid growth at these ages. Also, weight and BMI showed positive correlations with FVC, FEV_1, PEF, and FEF 25%-75%. Similar results were reported by Yao et al[21] who suggested that their results were independent of atopic status. Kongkiattikul et al[22] found a high prevalence (73%) of abnormal lung functions in obese children and adolescents. In addition, weight and BMI showed positive correlations with higher MIP, but Rosa et al[23] observed that overweight and obese children had lower MIP values. On the other hand, higher FVC/FEV_1 ratio correlated negatively with weight, as reported by Davidson et al[24] that obese participants had the lowest FEV_1/FVC ratio. Forno et al[25] also reported a significant decrease of FEF 25-75% and FEV_1/FVC ratio in obese asthmatic children.

Poorly controlled asthma not only impairs health-related quality of life in children, but also QOL of their caregivers. Therefore, proper treatment and management to improve symptom control may reduce both humanistic and economic burdens in asthmatic children and their parents[26]. We also observed that BF% positively correlated with higher PEF, FEF 25%-75%, MIP, and MEP showing better respiratory functions in children with higher BF%. There was a positive correlation in our study between MMSE and BMI. Previous reports support our data that greater adiposity predicted higher cognitive ability. These associations are only partly explained by better socio-economic factors. Moreover, better nutrition

is associated with better cognitive functions and inverse associations between adiposity and cognitive function in high-income countries reflect the confounding effect of socio-economic factors[27].

The limitations of our study are its cross-sectional design and relatively small sample size. More research studies at larger scale and with prospective designs are required to evaluate the QOL in asthmatic patients in addition to current management plans.

Conclusions

Our study showed that QOL in asthmatic children was significantly poor compared to healthy children in the domains of physical functioning and social life. However, the emotional aspects of QOL were not significantly affected in asthmatic children. Moreover, fatigability scores were higher in asthmatic children which might be due to the compromised functions of their respiratory system.

Recommendations

Long term prospective trials at large scale are needed to confirm the true relationship between the Asthma Control test score with Spirometry parameters, QOL and adiposity indices in asthmatic children.

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Conflict of Interests

The authors declare that they have no conflict of interest.

References

1) Asher I, Pearce N. Global burden of asthma among children. Int J Tuberc Lung Dis 2014; 18: 1269-1278.
2) Follenweider LM, Lambertino A. Epidemiology of asthma in the United States. Nurs Clin North Am 2013; 48: 1-10.
3) Lozano R, Naghavi M, Foreman K, Lim S, Shibuya K, Aboyans V, Abraham J, Adair T, Aggarwal R, Ahn SY, Alvarado M, Anderson HR, Anderson LM, Andrews KG, Atkinson C, Baddour LM, Barker-Collo S, Bartels DH, Bell ML, Benjamin EJ, Bennett D, Bhalla K, Bikbov B, Bin Abdulhak A, Birbeck G, Blyth F, Bolliger I, Boufous S, Bucello C, Burch M, Burney P, Carapetis J, Chen H, Chou D, Chugh SS, Coffeng LE, Colan SD, Colquhoun S, Colson KE, Condon J, Connor MD, Cooper LT, Corriere M, Cortinovis M, de Vaccaro KC, Couser W, Cowie BC, Criqui MH, Cross M, Dabhadkar KC, Dahodwala N, De Leo D, Degenhardt L, Delossantos A, Denenberg J, Des Jarlais DC, Dharmaratne SD, Dorsey ER, Driscoll T, Duber H, Ebel B, Erwin PJ, Espindola P, Ezzati M, Feigin V, Flaxman AD, Forouzanfar MH, Fowkes FG, Franklin R, Fransen M, Freeman MK, Gabriel SE, Gakidou E, Gaspari F, Gillum RF, Gonzalez-Medina D, Halasa YA, Haring D, Harrison JE, Havmoeller R, Hay RJ, Hoen B, Hotez PJ, Hoy D, Jacobsen KH, James SL, Jasrasaria R, Jayaraman S, Johns N, Karthikeyan G, Kassebaum N, Keren A, Khoo JP, Knowlton LM, Kobusingye O, Koranteng A, Krishnamurthi R, Lipnick M, Lipshultz SE, Ohno SL, Mabweijano J, MacIntyre MF, Mallinger L, March L, Marks GB, Marks R, Matsumori A, Matzopoulos R, Mayosi BM, McAnulty JH, McDermott MM, McGrath J, Mensah GA, Merriman TR, Michaud C, Miller M, Miller TR, Mock C, Mocumbi AO, Mokdad AA, Moran A, Mulholland K, Nair MN, Naldi L, Narayan KM, Nasseri K, Norman P, O'Donnell M, Omer SB, Ortblad K, Osborne R, Ozgediz D, Pahari B, Pandian JD, Rivero AP, Padilla RP, Perez-Ruiz F, Perico N, Phillips D, Pierce K, Pope CA 3rd, Porrini E, Pourmalek F, Raju M, Ranganathan D, Rehm JT, Rein DB, Remuzzi G, Rivara FP, Roberts T, De León FR, Rosenfeld LC, Rushton L, Sacco RL, Salomon JA, Sampson U, Sanman E, Schwebel DC, Segui-Gomez M, Shepard DS, Singh D, Singleton J, Sliwa K, Smith E, Steer A, Taylor JA, Thomas B, Tleyjeh IM, Towbin JA, Truelsen T, Undurraga EA, Venketasubramanian N, Vijayakumar L, Vos T, Wagner GR, Wang M, Wang W, Watt K, Weinstock MA, Weintraub R, Wilkinson JD, Woolf AD, Wulf S, Yeh PH, Yip P, Zabetian A, Zheng ZJ, Lopez AD, Murray CJ, AlMazroa MA, Memish ZA. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012; 380: 2095-2128.
4) Al-Moamary M, Alhaider S, Idrees M, Al-Ghobain M, Zeitouni M, Al-Harbi A. The Saudi initiative for asthma-2016 update: guidelines for the diagnosis and management of asthma in adults and children. Ann Thorac Med 2019; 14: 3-48.
5) Gomez-Llorente MA, Romero R, Chueca N, Martinez-Cañavate A, Gomez-Llorente C. Obesity and asthma: a missing link. Int J Mol Sci 2017; 18. pii: E1490.
6) Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, Mullany EC, Biryukov S, Abbafati C, Abera SF, Abraham JP, Abu-Rmeileh NM, Achoki T, AlBuhairan FS, Alemu ZA, Alfonso R, Ali MK, Ali R, Guzman NA, Ammar W, Anwari P, Banerjee A, Barquera S, Basu S, Bennett DA, Bhutta Z, Blore J, Cabral N, Nonato IC, Chang JC, Chowdhury R, Courville KJ, Criqui MH, Cundiff DK, Dabhadkar KC, Dandona L, Davis A, Dayama A, Dharmaratne SD, Ding EL, Durrani AM, Esteghamati A, Farzadfar F, Fay DF, Feigin VL, Flaxman A, Forouzanfar MH, Goto A, Green MA, Gupta R, Hafezi-Nejad N, Hankey GJ, Harewood HC, Havmoeller R, Hay S, Hernandez L, Husseini A, Idrisov BT, Ikeda N, Islami F, Jahangir E, Jassal SK, Jee SH, Jeffreys M, Jonas JB, Kabagambe EK, Khalifa SE, Kengne AP, Khader YS, Khang YH, Kim D,

Kimokoti RW, Kinge JM, Kokubo Y, Kosen S, Kwan G, Lai T, Leinsalu M, Li Y, Liang X, Liu S, Logroscino G, Lotufo PA, Lu Y, Ma J, Mainoo NK, Mensah GA, Merriman TR, Mokdad AH, Moschandreas J, Naghavi M, Naheed A, Nand D, Narayan KM, Nelson EL, Neuhouser ML, Nisar MI, Ohkubo T, Oti SO, Pedroza A, Prabhakaran D, Roy N, Sampson U, Seo H, Sepanlou SG, Shibuya K, Shiri R, Shiue I, Singh GM, Singh JA, Skirbekk V, Stapelberg NJ, Sturua L, Sykes BL, Tobias M, Tran BX, Trasande L, Toyoshima H, van de Vijver S, Vasankari TJ, Veerman JL, Velasquez-Melendez G, Vlassov VV, Vollset SE, Vos T, Wang C, Wang X, Weiderpass E, Werdecker A, Wright JL, Yang YC, Yatsuya H, Yoon J, Yoon SJ, Zhao Y, Zhou M, Zhu S, Lopez AD, Murray CJ, Gakidou E. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet 2014; 384: 766-781.

7) Habib SS, Alzoghaibi MA, Abba AA, Hasan M. Relationship of the Arabic version of the asthma control test with ventilatory function tests and levels of exhaled nitric oxide in adult asthmatics. Saudi Med J 2014; 35: 397-402.

8) Ricci G, Dondi A, Baldi E, Bendandi B, Giannetti A, Masi M. Use of the Italian version of the pediatric asthma quality of life questionnaire in the daily practice: results of a prospective study. BMC Pediatr 2009; 9: 30.

9) Culver BH, Graham BL, Coates AL, Wanger J, Berry CE, Clarke PK, Hallstrand TS, Hankinson JL, Kaminsky DA, MacIntyre NR, McCormack MC, Rosenfeld M, Stanojevic S, Weiner DJ; Recommendations for a Standardized Pulmonary Function Report. An official American Thoracic Society technical statement. ATS Committee on Proficiency Standards for Pulmonary Function Laboratories. Am J Respir Crit Care Med 2017; 196: 1463-1472.

10) Dimitriadis Z1, Kapreli E, Konstantinidou I, Oldham J, Strimpakos N. Test/retest reliability of maximum mouth pressure measurements with the MicroRPM in healthy volunteers. Respir Care 2011; 56: 776-782.

11) Global Asthma Network. The Global Asthma Report 2014. Auckland, New Zeal. 2014; http://www.globalasthmanetwork.org/news/GAR2014.php.

12) Petsios KT, Priftis KN, Hatziagorou E, Tsanakas JN, Antonogeorgos G, Matziou VN. Determinants of quality of life in children with asthma. Pediatr Pulmonol 2013; 48: 1171-1180.

13) Manion AB, Velsor-Friedrich B. Quality of life and health outcomes in overweight and non-overweight children with asthma. J Pediatr Health Care 2017; 31: 37-45.

14) Furtado PR, Maciel ÁCC, Barbosa RRT, Silva AAMD, Freitas DA, Mendonça KMPP. Association between quality of life, severity of asthma, sleep disorders and exercise capacity in children with asthma: a cross-sectional study. Braz J Phys Ther 2019; 23: 12-18.

15) Carey SK, Edds-McAfee C, Martinez V, Gutierrez de Blume AP, Thornton KM. An examination of factors affecting quality of life for children with asthma and their caregivers in Southeastern Georgia. J Pediatr Health Care 2019; 33: 529-536.

16) Padding AM, Rutjes NW, Hashimoto S, Vos A, Staphorst MS, van Aalderen WMC, van der Schee MP. Young children experience little emotional burden during invasive procedures in asthma research. Eur J Pediatr 2019; 178: 207-211.

17) Tikhonoff V, Casiglia E, Guidotti F, Giordano N, Martini B, Mazza A, Spinella P, Palatini P. Body fat and the cognitive pattern: a population-based study. Obesity 2015; 23: 1502-1510.

18) Smith E, Hay P, Campbell L, Trollor JN. A review of the association between obesity and cognitive function across the lifespan: implications for novel approaches to prevention and treatment. Obes Rev 2011; 12: 740-755.

19) Karachaliou F, Vlachopapadopoulou E, Psaltopoulou T, Manios Y, Koutsouki D, Bogdanis G, Carayianni V, Sergentanis T, Hatzakis A, Michalacos S. Prevalence of asthma symptoms and association with obesity, sedentary lifestyle and sociodemographic factors: data from the Hellenic National Action Plan for the assessment, prevention and treatment of childhood obesity (MIS301205). J Asthma 2018; 16: 1-7.

20) van Gent R, van Essen LE, Rovers MM, Kimpen JL, van der Ent CK, de Meer G. Quality of life in children with undiagnosed and diagnosed asthma. Eur J Pediatr 2007; 166: 843-848.

21) Yao TC, Tsai HJ, Chang SW, Chung RH, Hsu JY, Tsai MH, Liao SL, Hua MC, Lai SH, Chen LC, Yeh KW, Tseng YL, Lin WC, Chang SC, Huang JL; Prediction of Allergies in Taiwanese Children (PATCH) Study Group. Obesity disproportionately impacts lung volumes, airflow and exhaled nitric oxide in children. PLoS One 2017; 12: e0174691.

22) Kongkiattikul L, Sritippayawan S, Chomtho S, Deerojanawong J, Prapphal N. Relationship between obesity indices and pulmonary function parameters in obese Thai children and adolescents. Indian J Pediatr 2015; 82: 1112-1116.

23) Rosa GJ, Schivinski CIS. Avaliação da força muscular respiratória de crianças segundo a classificação do índice de massa corporal. Rev Paul Pediatr 2014; 32: 250-255.

24) Davidson WJ, Mackenzie-Rife KA, Witmans MB, Montgomery MD, Ball GDC, Egbogah S, Eves ND. Obesity negatively impacts lung function in children and adolescents. Pediatr Pulmonol 2014; 49: 1003-1010.

25) Forno E, Han YY, Mullen J, Celedón JC. Overweight, obesity, and lung function in children and adults-a meta-analysis. J Allergy Clin Immunol Pract 2018; 6: 570-581.

26) Dean BB, Calimlim BC, Sacco P, Aguilar D, Maykut R, Tinkelman D. Uncontrolled asthma: assessing quality of life and productivity of children and their caregivers using a cross-sectional internet-based survey. Health Qual Life Outcomes 2010; 8: 96.

27) Veena SR, Hegde BG, Ramachandraiah S, Krishnaveni GV, Fall CH, Srinivasan K. Relationship between adiposity and cognitive performance in 9-10-year-old children in South India. Arch Dis Child 2014; 99: 126-134.