European Journal of Applied Sciences 12 (1): 01-06, 2020
ISSN 2079-2077

DOI: 10.5829/idosi.ejas.2020.01.06

Assessment of Pulmonary Functions in Children According to the Body Mass Index

[1]*Mohamed H. Ahmed,* [2]*Samia A. Abdel Rahman and* [2]*Radwa S. Abdel Rahman*

[1]Physical Therapy Department, Elbajour General Hospital , Ministry of Health, Egypt
[2]Pediatric Physical Therapy Department,
Faculty of Physical Therapy, Cairo University, Giza, Egypt

Abstract: Background and Objective: Overweight andobesity become common among school children and adolescents. The relationship between obesity or overweight and pulmonary functions has not been investigated in children aged from 7-9 years previously. Therefore, we aimed to compare pulmonary functions among normal, overweight and obese schoolchildren. Methods:Ninety schoolchildren from primary schools of ShebinElkom, Monoufia governorate with age range of 7-9 years. According to the Body mass index (BMI) for-age percentile, they were categorized into 'normal weight' group (BMI-for-age percentile: 5^{th} to less than 85^{th}), 'overweight' group (85^{th} to less than 95^{th} percentile) and 'obese'group (95^{th} percentile or more) with 30 children in each group. Forced vital capacity (FVC), forced expiratory flow rate in one second (FEV1), FEV1/FVC and peak expiratory flow rate (PEFR) were measured by spirometer. Results: There was non-significant difference in FVC (p=0.409), FEV1 (p=0.465), FEV1/FVC (p=0.563) and PEFR (p=0.400) among normal, overweight and obese children. Conclusion: Overweight and obesity has no effect on pulmonary functions in children aged from 7 to 9 years.

Key words: Obesity · Body mass index · Pulmonary functions

INTRODUCTION

Obesity has been defined as an abnormal and excessive fat accumulation that may impair health in practice.Prevalence of obesity and overweight was found to be increased in both adults and children in developed and developing countries [1].

Weight category whether underweight, normal, overweight or obesecould be classified by the body mass index (BMI), which is taken as a substitution of percentage fat mass [2]. BMI is the metric currently in use for defining anthropometric height/weight characteristics and for classifying (categorizing) them into groups [3]. It can be defined as dividing weight (in kilograms) by height (in meters) squared. As an individual's height and weight can be easily and inexpensively measured, BMI has become a popular heuristic approximation for body fatness in epidemiology and clinical practice [4].

Obese individuals are more susceptible to many health problems such as obstructive sleep apnea, cardiovascular, pulmonary, hepatic, renal diseases, metabolic alterations and neoplasm [5]. The complications associated with obesity may be the following: hypertension, diabetes, psychosocial disorders related to acceptance in the group, and removal of group activities, sleep apnea, and increased ventilatory demand. When ventilatory demand increases, it is often accompanied by fatigue upon effort and limitations to carry out activities of daily living [6].

Respiratory function is a term used to describe how well the lungs work in helping a person breathes. During breathing, oxygen is taken into the lungs, where it passes into the blood and travels to the body's tissues. Carbon dioxide which is a waste product made by the body's tissues, is carried to the lungs, where it is exhalated. Lung function or Pulmonary function could be measured by different tests known as pulmonary function tests (PFTs) [7].

Pulmonary function tests (PFTs) are group of tests that measure how well the lungs work. This includes how well one is able to breathe and the efficiency of the lungs to deliver oxygen to the whole body [8].

Corresponding Author: Mohamed Hanea Ahmed, Physical Therapy Department, Elbajour General Hospital , Ministry of Health, Egypt. Tel: +201093707581.

Measurements that are made include: Forced expiratory volume in one second (FEV1), Forced vital capacity (FVC), the ratio of the two volumes (FEV1/FVC) and peak expiratory flow rate (PEFR) [9]. These measurements could be measured by spirometer [10].

Available data on pulmonary functions of children with overweight and obesity are conflicting [11-13]. There is limited information on effect of BMI on lung function in children. Therefore, this study was intended to compare pulmonary functions measured with spirometry among normal, overweight and obese schoolchildren.

MATERIALS AND METHODS

Study Design: A cross-sectional study was performed over the period from April 2019 to November 2019 at primary schools within municipality of Shebin Elkom, Monoufia governorate.

Subjects: Ninety schoolchildren of both gender with age ranged from 7 to 9 years residing in Shebin Elkom, Monoufia governorate participated in the study. The children did not participate according to the following exclusion criteria: upper or lower respiratory infections, chronic respiratory disorders such as asthma or interstitial lung disease, congenital abnormalities of cardiorespiratory system, chest deformities, neuromuscular diseases and FEV1 lower than 80% of the predicted [14].

Each child wasassigned into one of three equal groups according to the weight status category as follows: normal group (BMI-for-age percentile: 5th to less than 85th), overweight group (85th to less than 95th percentile) and obesegroup (95th percentile or more).

Materials:

A Digital Weight/height Scale: It was used to measure height to the last completed 0.1 cm and weight to the nearest 0.1 kg.

Spirometr: A portable spirometer (PIKO-1, UK) following the recommendation of the American Thoracic Society standards was used to measure FEV1, FVC and PEFR.

Spirometry is the term given to the basic lung function tests that measure the air that is expired and inspired. There are three basic related measurements: volume, time and flow. Spirometry is objective, noninvasive, sensitive to early change and reproducible. With the availability of portable meters, it can be performed almost anywhere and with the right training; it can be performed by anybody. It is performed to detect the presence or absence of lung disease, quantify lung impairment, monitor the effects of occupational/ environmental exposures and determine the effects of medications [15].

Procedures

Ethical Considerations: Approval from the Ministry of Education and the participated schools as well as written consents from children's parents or legal guardians were obtained before starting the study. After collecting the consents forms, the children will be examined by the school's physician for the inclusion and exclusion criteria. Each eligible child (according to the consent forms and medical examination) will participate in the study.

Calculating BMI-for-age Percentile: Weight and height were measured for all participants using weight/height scale (weight to the nearest 0.1 kg and height to the nearest 0.1 cm). BMI-for-age related percentile was measured by CDC BMI Percentile Calculator for Child and Teen (Available at: https: //www.cdc. gov/ healthyweight/ bmi/ calculator.html). This calculator provides BMI and the corresponding BMI-for-age percentile based on the CDC growth charts for children and teens (ages 2 through 19 years) [16].Depending on BMI-for-age percentile, the participants were classified into normal, overweight and obese groups.

Measurement of Pulmonary Functions: Pulmonary functions were measured by the spirometer, following the guideline given by the American Thoracic Society (ATS) [17]. The children reported after a light breakfast. The test was explained and demonstrated to the children. After a rest for 5-10 minutes, the test was carried out. The best of the three acceptable results was recorded.

The measured pulmonary functions in this study were FVC (the maximal volume of air exhaled with maximally forced effort from a maximal inspiration), FEV1 (the maximal volume of air exhaled in the first second of a forced expiration from a position of full inspiration), FEV1/FVC ratio and PEFR (The greatest rate of airflow that can be achieved during forced expiration, beginning with the lungs fully inflated) [18].

Statistical Analysis: Descriptive statistics were conducted to calculate the mean, standard deviation and the frequency of all the measured variables. One-way ANOVA was conducted for comparison of pulmonary functions among normal, overweight and obese groups.

SPSS for Windows statistical software version 20 was used for the analysis. The level of significance for all statistical tests was set at $p \leq 0.05$.

RESULTS

Ninety children were analyzed, thirty in each weight category. There was no significant difference among the three groups regarding gender, age and height (Table 1). Results revealed that BMI has no significant relationship to any of the measured pulmonary functions as there were non- significant differences among the three groups (Table 2).

DISCUSSION

The justification for the link between obesity and respiratory disorders are not completely comprehensed. Several possible mechanisms related to obesity have been investigated which may be causing respiratory problems especially asthmatic symptoms in obese individuals [19-21].

Overweight, obese, and morbidly obese individuals may have variables which differ from those individuals with normal weight, and which could have an effect on lung capacity and respiratory function. In adults, obesity leads to the reduction of the lung function because of the reduction of reserve volume and the functional vital capacity, which is caused by reduced chest wall and lung compliance [22, 23].

However, studies on children have found conflicting results. Lazarus *et al.* [10] examined the effect of total body fat as a percentage of weight on pulmonary function in a broadly representative sample of 2,464 Australian schoolchildren aged 9, 12, and 15 years. They stated that ventilatory function was negatively associated with the proportion of body weight. Tenório *et al.* [24] performed a systematic review of observational studies that analyzed the relation between pulmonary function measured by spirometer and presence of obesity in children and adolescents. The studies showed consistent data and evidence of association between decreased spirometric values of FVC and FEV1 with obesity in children and adolescents. Torun *et al.* [13] determined the impact of the degree of obesity on the pulmonary functions of schoolchildren and adolescent (9-17 years). They found that overweight, obese and morbidly obese children have no obstructive abnormalities compared with healthy lean children. Cofré *et al.* [25] examined the effect of BMI and waist-hip ratio (WHR) on functional residual capacity (FRC) in obese children aged from 6 to 12 years in Talca, Chile. They reported that the obese children showed a lower FRC compared to normal weight children, which, in turn, was associated with WHR.

Table 1: Comparison of gender, age and height among the three different weight status categories.

	Weight Status Categories							
	Normal N=30		Overweight N=30		Obese N=30			
	N	%	N	%	N	%	Test of Significance	*p*
Gender								
Male	18	60.0	13	43.3	13	43.3	x^2=2.223	0.329
Female	12	40.0	17	56.7	17	56.7		
Age (years)								
Mean±SD	8.17± 0.87	8.20 ± 0.85	7.93 ± 0.94	F=0.800	0.452			
Height								
Mean±SD	129.90±10.77	129.03±11.13	126.60±10.52	F=0.752	0.475			

N: Number. %: Percentage. SD: Standard deviation. x^2: Chi square test F: ANOVA test. *p*: Probability value (Significant at $p \leq 0.05$).

Table 2: Comparison of pulmonary functions among the three different weight status categories.

	Weight Status Categories				
Pulmonary	Normal N=30	Overweight N=30	Obese N=30		
Functions	Mean±SD			F	*p*
FVC	1.77±0.41	1.74±0.36	1.89±0.59	0.904	0.409
FEV1	1.58±0.38	1.52±0.33	1.65±0.50	0.773	0.465
FEV1/FVC	88.67±5.27	87.47±5.89	87.23±5.42	0.579	0.563
PEFR	2.94±0.70	2.78±0.70	2.71±0.60	0.926	0.400

N: Number. SD: Standard deviation. FVC: Forced vital capacity. FEV1: Forced expiratory volume in one second. PEFR: Peak expiratory flow rate. F: ANOVA test. *p*: Probability value (Significant at $p \leq 0.05$).

The results of our study did not show any significant effect of obesity or overweight on pulmonary functions measured by spirometer on children aged from 7 to 9 years.

The results of our study were supported by Liyanage *et al.* [26] who showed that there was no significant relationship between obesity and any of the pulmonary function parameters and reported that FVC, FEV1 and FEV1/FVC have no relation with BMI in childrenaged between 9-15 years.

Köksal and Özbek [27] also agree with our results as they compared between normal and obese children with mild asthma and revealed that obesity didn't seem to affect pulmonary functions in children with well-controlled mild persistent asthma. They stated that FVC, FEV1 and FEV1/FVC showed non-significant difference between obese and normal groups.

Body mass index for age percentage was negatively correlated with FEV1 and FEV1/FVC according to Akýn *et al.* [28]. Also, there was no relation between obesity and FVC and PEFR. However, when they used other obesity indicators such as waist and neck circumference, BMI for age percentage showed no relation with FEV1 or FEV1/FVC.

Del Rio-Navarro *et al.* [29] showed non-significant difference in FEV1 between normal and obese children. Also, they showed a significant increase in FVC and PEFR in obese group. We can explain this because of the different age group which included children with adolescents.

However, Ulger *et al.* [30], Spathopoulos *et al.* [31] and Naidu and Reddy [18] reported significant decrease of FVC, FEV1, FEV1/FVC and PEFR in obese children. All these studies included older children and adolescents which mean that the relation between obesity and pulmonary functions seems to appear in old children and adolescents not in early school children.

This inconsistency observed between studies investigating relationship between spirometry parameters and obesity/overweight could be explained in many ways. Methodological differences such as different criteria in measuring the fat mass or sample size may have played a role. Further, distribution of body fat in different populations, degree of obesity and duration of obesity in the samples recruited may have an effect on pulmonary function. This variability in results may also be due to positive effect of growth is covering the negative effects of obesity on pulmonary function.

In general, BMI is considered a measure of obesity and it cannot distinguish fat and lean body mass. It is an index of nutritional status and its relationship with body composition is controversial. When compared with other measurements, accuracy and precision of skin fold thickness measurements is poor in obese children [32]. However, it can be used to predict body composition. Waist circumference provides a simple measure of central fatness and it may have a direct effect on the chest wall properties. In addition, there are more sophisticated techniques of assessing fat mass in children. Bioelectric impendence analysis (BIA) and Dual energy X-ray absorptiometry (DXA) have the possibility to improve accuracy and predicts the body composition. Therefore, selecting a method which measures body fat composition accurately would have given different results to what we have found in this study.

Limitations: There are some limitations in our study. A bigger sample size may more appointed evidence. Although BMI is the widely acceptable method for assessing obesity, it does not differentiate the lean mass and fat mass in an individual. Therefore, a method which assesses the body composition might give more accurate results. In our study we have only investigated the dynamic lung volumes since we did not have facilities to examine static lung volumes and ventilation-perfusion relationship in children.

CONCLUSION

Obesity evaluated by BMI-for-age has no effect on pulmonary functions in children aged from 7 to 9 years. Results showed non-significant difference among normal, overweight and obese children.

REFERENCES

1. Katulanda, P., M.A. Jayawardena, M.H. Sheriff, G.R. Constantine and D.R. Matthews, 2010. Prevalence of overweight and obesity in Sri Lankan adults. Obesity Review, 11(11): 751-756.
2. Müller, M. and C. Geisler, 2017. Defining obesity as a disease. European Journal of Clinical Nutrition, 71(11): 1256-1258.
3. Nuttall, F.Q., 2015. Body Mass Index. Nutrition Today, 50(3): 117-128.

4. Sperrin, M., A. Marshall, V. Higgins, A. Renehan and I. Buchan, 2015. Body mass index relates weight to height differently in women and older adults: serial cross-sectional surveys in England (1992-2011). Journal of Public Health, 38(3): 607-613.
5. Melo, L.C., M.A. Silva and A.C. Calles, 2014. Obesity and lung function: a systematic review. Einstein (Sao Paulo), 12(1): 120-125.
6. Mello, E.D., V.C. Luft and F. Meyer, 2004. Childhood obesity: Towards effectiveness. Journal of Pediatrics, 80(3): 173-182.
7. National Cancer Institute, 2018. NCI Dictionary of Cancer Terms. [online]Available at: https://www.cancer.gov/publications/ dictionaries/cancer-terms/def/lung-function [Accessed 17 Sep. 2018].
8. Martel, J., 2017. Pulmonary Function Test. Healthline [Online] Available at: https://www.healthline.com/health/pulmonary-function-tests [Accessed 7 Sep. 2018].
9. Ranu, H., M. Wilde and B. Madden, 2011. Pulmonary Function Tests. Ulster Medical, 80(2): 84-90.
10. Irfan, M., A. Jabbar, A. Haque, S. Awan and S. Hussain, 2011. Pulmonary functions in patients with diabetes mellitus. Lung India, 28(2): 89-92.
11. Lazarus, R., G. Colditz, C.S. Berkey and F.E. Speizer, 1997. Effects of body fat on ventilatory function in children and adolescents: Cross-sectional findings from a random population sample of school children. Pediatric Pulmonology, 24(3): 187-194.
12. Paralikar, S.J., R.G. Kathrotia, N.R. Pathak and M.B. Jani, 2012. Assessment of pulmonary functions in obese adolescent boys. Lung India, 29(3): 236-240.
13. Torun, E., E. Cakir, F. Ozguç and I.T. Ozgen, 2014. The effect of obesity degree on childhood pulmonary function tests. Balkan Medical Journal, 31(1): 235-238.
14. Polgar, C. and T.R. Weng, 1979. The functional development of the respiratory system from the period of gestation to adulthood. American Review of Respiratory Disease, 120(3): 625-695.
15. Moore, V., 2012. Spirometry: step by step. Breathe, 8(3): 232-240.
16. Centers for Disease Control and Prevention, 2018. Body Mass Index (BMI) [Online]. Available at: https://www.cdc.gov/healthyweight/assessing/bmi/ [Accessed 20 Mar. 2019].
17. Miller, M.R., J. Hankinson, V. Brusasco, F. Burgos, R. Casaburi, A. Coates, R. Crapo, P. Enright, C.P.M. van der Grinten, P. Gustafsson, R. Jensen, D.C. Johnson, N. MacIntyre, R. McKay, D. Navajas, O.F. Pedersen, R. Pellegrino, G. Viegi and J. Wanger, 2005. Standardization of spirometry. European Respiratory Journal, 26(2): 319-338.
18. Naidu, M. and P.A. Reddy, 2018. Pulmonary function tests in obese and overweight children aged 5-16 years: A case-control study. Journal of Pulmonary Medicine and Respiratory Diseases, 2019(1): 28-36.
19. Fantuzzi, G., 2005. Adipose tissue, adipokines, and inflammation. Journal of Allergy and Clinical Immunology, 115(5): 911-919.
20. McLachlan, C.R., R. Poulton, G. Car, J. Cowan, S. Filsell, J.M. Greene, D.R. Taylor, D. Welch, A. Williamson, M.R. Sears and R.J. Hancox, 2007. Adiposity, asthma and airway inflammation. Journal of Allergy and Clinical Immunology, 119(3): 634-639.
21. Santamaria, F., S. Montella, S. De Stefano, F. Sperlì, F. Barbarano, R. Spadaro and A. Franzese, 2007. Asthma, atopy, and airway inflammation in obese children. Journal of Allergy and Clinical Immunology, 120(4): 965-967.
22. Zerah, F., A. Harf, L. Perlemuter, H. Lorino, A.M. Lorino and G. Atlan, 1993. Effects of obesity on respiratory resistance. Chest, 103(5): 1470-1476.
23. Pankow, W., T. Podszus, T. Gutheil, T. Penzel, J.H. Peter and P. Von Wichert, 1998. Expiratory flow limitation and intrinsic positive end-expiratory pressure in obesity. Journal of Applied Physiology, 85(4): 1236-1243.
24. Tenório, L.H.S., A. Santos, A.S. de Oliveira, A.M.J. de Lima and M.S. Brasileiro-Santos, 2012. Obesity and pulmonary function tests in children and adolescents: a systematic review. Revista Paulista de Pediatria, 30(3): 423-30.
25. Cofré, R.M., M. del Sol, P.M. González, J.E. Inostroza, P.A. Lizana, D. Conei and M.E. Cabello, 2019. Relation among body mass index, waist-hip ratio, and pulmonary functional residual capacity in normal weight versus obese Chilean children: A cross-sectional study. ArchivosArgentinos de Pediatria, 117(4): 230-236.
26. Liyanage, G., B.D. Jayamanne, M. Aaqiff and D. Sriwardhana, 2016. Effect of body mass index on pulmonary function in children. Ceylon Medical Journal, 61(4): 163-166.

27. Köksal, B.T. and Ö.Y. Özbek, 2016. Effect of obesity on pulmonary function in children with mild persistent asthma. Asthma Allergy Immunology, 14(2): 56-63.
28. Akýn, O., M. Arslan, C. Haymana, E. Karabulut, B. Hacihamdioglu and S.T. Yavuz, 2017. Association of neck circumference and pulmonary function in children. Annals of Allergy, Asthma & Immunology, 119(1): 27-30.
29. Del Rio-Navarro, B.E., V. Blandon-Vijil, A.J. Escalante-Domínguez, A. Berber and J.A. Castro-Rodriguez, 2013. Effect of obesity on bronchial hyperreactivity among Latino children. Pediatric Pulmonology, 48(12): 1201-1205.
30. Ulger, Z., E. Demir, R. Tanaç, D. Gökşen, F. Gülen, S. Darcan, D. Can and M. Coker, 2006. The effect of childhood obesity on respiratory function tests and airway hyperresponsiveness. The Turkish Journal of Pediatrics, 48(1): 43-50.
31. Spathopoulos, D., E. Paraskakis, G. Trypsianis, A. Tsalkidis, V. Arvanitidou, M. Emporiadou, D. Bouros and A. Chatzimichael, 2009. The effect of obesity on pulmonary lung function of school aged children in Greece. Pediatric Pulmonology, 44(3): 273-280.
32. Wells, J.C.K. and M.S. Fewtrell, 2006. Measuring body composition. Archives of Disease in Childhood, 91(7): 612-617.