



## Impact of sports activities on respiratory function and mechanics in children

### *Repercussões da prática de atividade esportiva na função e mecânica respiratória de crianças*

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#### Abstract

**Introduction:** Being physically active in childhood may improve the quality of life in adulthood. So, it is extremely important to evaluate the respiratory function and mechanics of children who participate in sports activities, in order to determine the impact of physical activity on airway resistance. **Objective:** To analyze measures of respiratory function and mechanics in children who participate (PG) and who do not participate (CG) in sports activities regularly, as well as to compare and correlate the results. **Methods:** This is a cross-sectional analytical study of healthy school-aged children aged 6 to 12 years, assessed by impulse oscillometry tests (IOS) and spirometry. The sample was divided into PG and CG. The Student's t-Test or Mann-Whitney test was used to compare the groups according to normality of data tested by the Shapiro-Wilk test. The correlation between the tests and age, sex, weight, height and body mass index (BMI) was performed using Pearson's and Spearman correlation coefficient. Statistical data were processed by the SPSS® software, considering significance level at  $p < 0.05$ . **Results:** Forty children participated in the study, 20 in each group, with no differences regarding age, sex, weight, height and BMI. There were significant

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differences in FEF25-75% (CG: 94.19%  $\pm$  13.08 x PG: 101.75%  $\pm$  17.44,  $p = 0.049$ ), and oscillometry data did not differ between both groups. Sex correlated with total airway resistance (R5 -  $p = 0.049$ ,  $r = 0.314$ ). **Conclusion:** In the group with children who participated in sports activities, FEF25-75% was higher, compared to the control group.

**Keywords:** Respiratory Mechanics. Spirometry. Child. Sports Activities.

## Resumo

**Introdução:** Ser ativo fisicamente na infância pode proporcionar ao indivíduo uma melhor qualidade de vida na idade adulta. Assim, a avaliação da função e da mecânica respiratória de crianças praticantes de atividade esportiva para a detecção das repercussões da atividade física nos parâmetros de resistências das vias aéreas é extremamente importante. **Objetivo:** Analisar medidas da função e da mecânica respiratória de crianças, praticantes (GP) e não praticantes de atividade esportiva regular (GC), comparar e correlacionar os resultados. **Métodos:** Estudo analítico transversal realizado com crianças saudáveis em idade escolar de 6 a 12 anos, avaliadas segundo os exames de oscilometria de impulso (IOS) e espirometria. A amostra foi dividida em GP e GC. Para a comparação dos grupos utilizou-se o teste t de Student ou Mann-Whitney, de acordo com a normalidade dos dados pelo teste de Shapiro-Wilk. A correlação entre os exames e as variáveis idade, sexo, peso, altura e índice de massa corpórea (IMC) foi realizada pelo coeficiente de Pearson e Spearman. Os dados foram processados pelo software SPSS®, considerando significativo  $p < 0,05$ . **Resultados:** Participaram 40 crianças, 20 em cada grupo, que não diferiram em relação à idade, sexo, peso, altura e IMC. Houve diferença significativa no parâmetro espirométrico FEF25-75% (GC: 94,19%  $\pm$  13,08 x GP: 101,75%  $\pm$  17,44,  $p = 0,049$ ) e os dados oscilométricos não foram diferentes entre os grupos. O sexo se correlacionou com a variável de resistência total das vias aéreas (R5 -  $p = 0,049$ ,  $r = 0,314$ ). **Conclusão:** No grupo de crianças praticantes de atividade esportiva, o parâmetro espirométrico de FEF25-75% apresentou-se maior em comparação ao grupo controle.

**Palavras-chave:** Mecânica respiratória. Espirometria. Criança. Exercícios Físicos.

## Introduction

For the American College of Sports Medicine (ACSM) and the Center for Disease Control (CDC), all children older than two years should perform thirty minutes of moderate to severe physical activity at least five days per week, or preferably, every day of the week (1).

In children, although research involving the impact of routine physical activity in respiratory mechanics is rather scarce, it is recommended that physical activity be encouraged and started at an early age. This should be a habit of a lifetime and one of its advantages is to maintain health and physical fitness in old age (2, 3). Also, being physically active in childhood enhances the quality of life of individuals in adulthood (4).

A recent systematic review confirms that physical activity favors all body functions and the metabolism of carbohydrate and lipid, helps to control blood

pressure, reduces the risk of type 2 diabetes, improves body composition, self-perception, the mood, self-image and intellectual function, thus contributing to improve the quality of life of children and adolescents (5). Despite consensus on these benefits, there are still few studies that relate healthy children who perform regular physical activity and their respective physiological adaptations (2, 3). Even less frequent are researches involving healthy school-aged children who play sports (1). Sports activities differ from physical activities because those include athletic activities requiring physical skills and often involve institutionally regulated competitive activities (6). Following this approach, some publications report the effects of different sports modalities on the daily routine of children with lung diseases (7 - 9).

In this context, spirometry has been the most frequently used test to monitor this population, as in the study conducted by Wicher et al. (6), which investigated lung function of children with asthma

before and after a three-month swim training program. Spirometry has been considered a valid and useful method for the diagnosis and monitoring of the development of pediatric respiratory diseases (9), despite the challenges of its implementation in preschool age, due to the difficulty of understanding and collaboration for its implementation (6).

Notably, impulse oscillometry system (IOS) has been increasingly used in the analysis of respiratory mechanics of lung diseases in children. This is a simple technique, of fast execution, and requires little patient's cooperation, which has enabled its wide application in children and the elderly (10 - 12). IOS allows the identification of obstructive patients, helps locate the obstruction area, has proven effective for the diagnosis of chronic obstructive pulmonary disease (COPD), and plays an important role as complementary analysis to spirometry for patients with asthma (13, 14).

These tools have been increasingly used in clinical practices (6, 9 - 12) due to their sensitivity and scientific recognition. Thus, their application to evaluate the respiratory function and mechanics of children who participate in sports activities may identify the impact of physical activity on airway resistance, which should be further investigated. Therefore, the aim of this study is to analyze and compare measurements of respiratory function and mechanics in children who participate in sports activities regularly or not.

## Methods

This is a cross-sectional, exploratory and analytical study including healthy children from two private schools in the metropolitan area of Florianópolis, in Santa Catarina (SC). The children aged 6 to 12 years and 11 months and attended the 2nd to 5th years of primary school. This study was approved by the Ethics Committee for Research Involving Human Beings of the Center for Sports and Health Sciences at the University of the State of Santa Catarina (No. 42/2011).

All participants received an Informed Consent Document (ICD), as well as a questionnaire with information about health history, daily activities and participation of sports activities (sport type and frequency), which was completed and signed by the parent or guardian.

## Sample Preparation

This was a non-probability sampling with intentionally selected units, including healthy school-aged children who participated in sports activities regularly or not, whose completed questionnaire showed that they were healthy, and who were recruited from two private schools in the metropolitan area of Florianópolis (SC). Children with a history of cardiopulmonary, musculoskeletal and/or neurological diseases, passive smokers and children with forced expiratory volume in one second (FEV<sub>1</sub>) below 80% of predicted (15), measured by spirometry, were excluded. A total of 124 school-aged children were assessed, and 48 children were excluded due to spirometry values below those recommended by the Brazilian Society of Pneumology (BSP). Thirty-six individuals were excluded as they failed to complete the assessments due to inability or lack of comprehension of the test. The final total sample included 40 children.

Based on the information collected by the questionnaire, the participants were divided into two groups: a group of children who participated in sports activities regularly (PG), *i.e.* who played any type of sports for 120 minutes at least twice a week during at least six months, and whose training frequency had been confirmed based on a structured questionnaire; and the control group (CG) with children who did not play any specific sports.

## Data Collection

Data was collected using Spirometry and IOS. All participants were instructed to wear comfortable clothes, to rest for at least 5 to 10 minutes, not to fast or be in any kind of food diet (16). Before the assessments, they had their weight (analog G-Tech scale, in kilograms) and height (measuring tape, in centimeters) measured by a single examiner for subsequent calculation of body mass index (BMI) (17).

Spirometry and IOS were performed with a Jaeger Pneumotacograph MasterScreen™ Impulse Oscillometry System (IOS) with previous volume calibration using a 3-liter syringe. The measurements were performed by the same examiner, in a quiet environment and previously conditioned with

temperature lower than or equal to 23 °C, using a Thermo-Hygrometer (18). During the tests, the children remained in a sitting position, keeping their heads in a neutral position. They received verbal instructions during the respiratory maneuvers and used individual disposable nozzles. Also, a nose clip was placed to minimize the loss of pressure through the upper airway shunt and air escape.

During the spirometry test, the children were asked to perform maximal inspiration followed by exhalation of the entire volume of air with maximum effort, in order to obtain forced expiratory volume in one second (FEV<sub>1</sub>), forced vital capacity (FVC), peak expiratory flow (PEF) and forced expiratory flow between 25% and 75% of FVC (FEF<sub>25-75%</sub>) in absolute numbers and percentages of specific predicted values for children, according to Polgar and Weng (15). The tests followed the acceptability and reproducibility criteria of the Brazilian Society of Pneumology and Phthysiology (SBPT), and produced at least three acceptable curves and two reproducible curves. The duration of each maneuver was at least 6 seconds, for a maximum of 8 attempts (18).

To measure IOS, the examiners held their hands on the children's cheeks, as they breathed in tidal volume, calmly, without talking or coughing (19). The maneuver was acceptable when the time segment selected for analysis lasted at least 20 seconds (20). The oscillometry parameters considered were: Peripheral Resistance (PerRes), Central Resistance (CentRes); Resistance at 20Hz (R20: resistance of the central airways), Resistance at 5Hz (R5: resistance of peripheral airways), Resonance Frequency (Fres), Reactance (X) and Impedance (Z) (11). There are no reference values established for the Brazilian pediatric population.

### Statistical analysis

After the statistical data have been collected, an individual report with numerical parameters related

to the studied variables and respective graphs was produced. The relevant numerical parameters were entered into a Microsoft Excel 2010 spreadsheet, and then, into the Statistical Package for Social Sciences (SPSS) 20.0 for Windows for further statistical analysis. Initially, the Shapiro-Wilk test was used to determine normality of data, and, according to this distribution, the Student's t-Test or the Mann-Whitney test was used for comparisons between the groups (PG x CG). The Chi-square test was used to compare the variable "sex". To correlate IOS parameters, the Spearman and Pearson tests were performed, considering age, sex, weight, height and BMI. The significance level was set at 0.05. The results were expressed as descriptive statistics and frequencies, using average and standard deviation.

### Results

The final sample consisted of 40 school-aged children, 20 in PG and 20 in CG. PG was composed of 12 boys (60%) and CG 13 (65%), with no statistical difference between frequencies of the variable "sex" ( $p = 0.113$ ). Table 1 describes data of the sample related to weight, height, age and BMI, with no statistical difference between the groups.

Regarding the spirometry data (Table 2), only the percentage of the predicted value for FEF<sub>25-75%</sub> was different between both groups, and lower in CG ( $94.19\% \pm 13.08$  x  $101.75\% \pm 17.44$ ;  $p = 0.049$ ). The evaluated oscillometry parameters did not differ between the groups (Table 2). However, both total resistance (R5) and central airway resistance (R20) were numerically higher in CG. R5 was  $5.37 \pm 1, 04$  cmH<sub>2</sub>O/l/s in CG versus  $4.86 \pm 1.08$  cmH<sub>2</sub>O/l/s in PG; and R20 was  $7.08 \pm 1.42$  cmH<sub>2</sub>O/l/s in the CG versus  $6.78 \pm 1.72$  cmH<sub>2</sub>O/l/s in PG.

There was no correlation between oscillometry data and age, height, weight and BMI. A weak positive correlation (21) could be observed only between sex and total airway resistance ( $p = 0.049$ ,  $r = 0.314$ ).

**Table 1** - Characterization of the sample according to age, weight, height and BMI

		Min.	Max.	A	SD	p
Age (years)	PG	6	10	8.10	1.16	0.718
	CG	7	9	8.35	0.58	
Weight (kilograms)	PG	21	56	30.87	8.50	0.904
	CG	21	40	30.2	5.52	
Height (meters)	PG	1.20	1.46	1.33	0.07	0.799
	CG	1.18	1.49	1.33	0.08	
BMI (Kg/m <sup>2</sup> )	PG	12.40	29.41	17.25	3.66	0.989
	CG	13.32	21.09	16.83	2.26	

Note: PG = group of children who participate in sports activities; CG = control group; Min. = minimum; Max. = maximum; A = average; SD = standard deviation; BMI = body mass index; Kg/m<sup>2</sup> = kilogram per square meter; p = statistical significance according to the Student's t-Test or Mann-Whitney test.

**Table 2** - Distribution of spirometry and oscillometry parameters for PG and CG, as well as statistical significance of the comparison between the groups

Parameters	Group	n	A	SD	p
FVC%	CG	20	94.72	10.83	0.730
	PG	20	97.37	12.10	
FEV <sub>1</sub> %	CG	20	95.83	8.48	0.671
	PG	20	98.21	10.36	
FEF <sub>25-75%</sub> %	CG	20	94.19	13.08	<b>0.049*</b>
	PG	20	101.75	17.44	
PerRes (cmH <sub>2</sub> O/l/s)	CG	20	4.41	0.94	0.061
	PG	20	4.20	1.53	
CentRes (cmH <sub>2</sub> O/l/s)	CG	20	3.52	1.04	0.104
	PG	20	3.14	1.32	
Fres (Hz)	CG	20	13.68	6.55	0.414
	PG	20	15.73	7.64	
R20 (cmH <sub>2</sub> O/l/s)	CG	20	5.37	1.04	0.954
	PG	20	4.86	1.08	
R5 (cmH <sub>2</sub> O/l/s)	CG	20	7.08	1.42	0.978
	PG	20	6.78	1.72	
Z (cmH <sub>2</sub> O/l/s)	CG	20	7.27	1.36	0.687
	PG	20	6.92	1.79	
X (cmH <sub>2</sub> O/l/s)	CG	20	-1.16	0.68	0.863
	PG	20	-1.56	0.69	

Note: PG = group of children who participate in sports activities; CG = control group; A = average; SD = standard deviation; FVC% = percentage of predicted Forced Vital Capacity; FEV% = percentage of predicted Forced Expiratory Volume; FEF<sub>25-75%</sub> = percentage of predicted Forced Expiratory Flow at 25-75%; PerRes = periphery resistance; CentRes = central resistance; R20 = resistance at 20 hertz; R5 = resistance at 5 hertz; Fres = resonance frequency; X = reactance; Z = impedance; p = statistical significance according to Student's t-Test or Mann-Whitney test (MW) (< 0.05); \* = statistically significant difference.

## Discussion

The management of lung diseases in children is well-established and, therefore, there are several acknowledged instruments in the literature for this type of monitoring, such as spirometry. However, the applicability and effectiveness of this type of examination

to evaluate pulmonary function in healthy children who perform physical activity are not part of systematic investigation of pediatric clinical research. In this context, the aim of this study was to prevent and inform about the impact of sports activities on the respiratory system in children.



The effectiveness of spirometry is evidenced in the literature, as described by Linares (22) in a study conducted in Chile. It is also the most widely used evaluation method for research on respiratory diseases (6, 23 - 27). A recent Brazilian study discusses the importance to analyze respiratory function in children (9). But, there is a consensus on the difficulty to implement this procedure in this age group, which justifies the use of additional tools, such as IOS, also used in this current study.

The use of IOS is relatively new and less frequent, but its feasibility, reliability and strong potential in care management of patients with asthma have been identified (13, 28). IOS does not need forced maneuvers, unlike spirometry (10), and therefore, it has been widely reported in Europe and studies analyzing risk factors for respiratory diseases (29 - 31). However, there are no reference values for the Brazilian population. Thus, this article aims to compare the absolute values of the investigated variables.

In this context, this is a pioneer study about the impact of the participation in regular sports activity on airway resistance parameters assessed by impulse oscillometry. The results found no significant differences between both groups regarding the investigated variables; however, numerically higher values of R5 and R20 were observed in CG. A larger sample size is likely to provide further support for this finding and for the idea that sports activities are beneficial for the body functions, as already reported in the literature (4, 5, 32), as well as for the respiratory mechanics in healthy children.

Sex influenced IOS parameters, identified by its correlation with R5 and Z in the total sample. These results are consistent with the literature, which shows a relation between sex and 30% of lung variation, and male have higher lung volumes (33, 34) and higher values of FVC, FEV1 and FEF<sub>25-75%</sub> (35).

Importantly, studies analyzing the correlation of IOS parameters with different variables identified a relationship between these and anthropometric characteristics, mainly height (20, 36). In contrast, this finding could not be observed in this study.

Regarding the spirometry findings, there were only differences in the percentage of the predicted value for FEF<sub>25-75%</sub>, which was higher in PG. These results support studies involving bronchial asthma (6, 7, 37, 38) and cystic fibrosis (39 - 41), in which sports activity improved lung function parameters.

As in physical activity, it is well known that the benefits of sports activities are temporary, but they can only be maintained if performed on a regular and consistent manner. This suggests that better effects can be achieved if sports activities begin in childhood and persist into adulthood (4). Thus, it is fundamental that sports be promoted at a young age. Specifically in the respiratory system, studies have shown improved sensation of dyspnea, increased exercise capacity, increased peak expiratory flow and quality of life with this healthy habit (7, 8).

The main limitations of this study involve the group of children who participate in sports activities, as they were included without the application of a questionnaire validated by the literature. Also, the sports modalities were not addressed and the minimal time for physical activity was not controlled. Moreover, this was a convenience sampling and there was no sample size calculation. We believe that the combination of all factors may have influenced the results.

However, the authors recommend that further studies could be conducted to assess the respiratory function and mechanics in different populations, especially in children. Researches involving the impact of sports activities on children's respiratory function should also be carried out, since promoting healthy habits during early childhood will bring lifelong benefits.

## Conclusion

In the group of children who participate in sports activities, FEF<sub>25-75%</sub> was higher compared to the control group. Impulse oscillometry parameters did not differ between both groups and sex correlated with total airway resistance.

## References

1. Alves JGB. Atividade física em crianças: promovendo a saúde do adulto. *Rev Bras Saude Mater Infant.* 2003;3(1):5-6.
2. Pimenta APAA, Palma A. Perfil epidemiológico da obesidade em crianças: relação entre televisão, atividade física e obesidade. *Rev Bras Ciên e Mov.* 2001;9(4):19-24.

3. Alves C, Lima RVB. Impacto da atividade física e esportes sobre o crescimento e puberdade de crianças e adolescentes. *Rev Paul Pediatr*. 2008;26(4):383-91.
4. Knuth AG, Hallal PC. School environment and physical activity in children and adolescents: systematic review. *Rev Bras Ativ Fis Saúde*. 2012;17(6):463-73.
5. Lemos DMC, Dallos CJO. Actividad física en niños y adolescentes: Determinantes y medición. *Salud UIS*. 2010;42(2):153-65.
6. Wicher IB, Ribeiro MAGO, Marmo DB, Santos CIS, Toro AADC, Mendes RT, et al. Avaliação espirométrica e da hiper-responsividade brônquica de crianças e adolescentes com asma atópica persistente moderada submetidos a natação. *J Pediatr*. 2010;86(5):384-90.
7. Basaran S, Guler-Uysal F, Ergen N, Seydaoglu G, Karakoç GB, Altintas DU. Effects of physical exercise on quality of life, exercise capacity and pulmonary function in children with asthma. *J Rehabil Med*. 2006;38(2):130-5.
8. Blau H, Georgy HM, Fink G, Kaye C, Szeinberg A, Spitzer SA, et al. Effects of an intensive 4-week summer camp on cystic fibrosis-pulmonary function, exercise tolerance, and nutrition. *Chest*. 2002;121(4):1117-22.
9. Veras TN, Pinto LA. Viabilidade da realização de espirometria em pré-escolares. *J BrasPneumol*. 2011;37(1):69-74.
10. Cardoso AP, Pereira JMR. Oscilometria de impulso: Novo método de avaliação da função respiratória. *Rev Port Pneumol*. 1998;4(2):175-205.
11. Moreira MAF. A Contribuição da Oscilometria de Impulso na Obstrução das Vias Aéreas [dissertation]. Porto Alegre (Brazil): Universidade Federal do Rio Grande do Sul; 2005.
12. Al-Mutairi SS, Sharma PN, Al-Alawi A, Al-Deen JS. Impulse oscillometry: an alternative modality to the conventional pulmonary function test to categorise obstructive pulmonary disorders. *Clin Exp Med*. 2007;7(2):56-64.
13. Cavalcanti JV, Lopes AJ, Jansen JM, Melo PL. Técnica de oscilações forçadas na análise da resposta broncodilatadora em voluntários sadios e indivíduos portadores de asma brônquica com resposta positiva. *J Bras Pneumol*. 2006;32(2):91-8.
14. Fiorot D, Faria ACD, Nascimento PS, Lopes AJ, Jansen JM, Melo PL. Validação do uso da técnica de oscilações forçadas no diagnóstico da doença pulmonar obstrutiva crônica. *IFMBE Proceedings*. 2007;18(12):1010-4.
15. Polgar C, Weng TR. The functional development of the respiratory system from the period of gestation to adulthood. *Am Rev Respir Dis*. 1979;120(3):625-95.
16. Ferreira JMR, Cardoso AP. O Papel da Oscilometria de Impulso no Rastreamento de Alterações Funcionais Respiratórias numa Amostra da População Portuguesa. *Rev Port Pneumol*. 1999;5(4):387-92.
17. Ministério da Saúde. Brasil: Programa Telesaúde Brasil, 2012 [cited 2012 Oct 7]. Available from <http://tinyurl.com/j9xd7xb>.
18. Sociedade Brasileira de Pneumologia. Diretrizes para Testes de Função Pulmonar. *J Pneumol*. 2002;28(3):1-82.
19. Beydon N, Davis SD, Lombardi E, Allen JL, Arets HG, Aurora P, et al. An official American Thoracic Society/European Respiratory Society statement: pulmonary function testing in preschool children. *Am J Respir Crit Care Med*. 2007;175(12):1304-45.
20. Malmberg LP, Pelkonen A, Poussa T, Pohjanpalo A, Haahtela T, Turpeinen M. Determinants of respiratory system input impedance and bronchodilator response in healthy Finnish preschool children. *Clin Physiol Funct Imaging*. 2002;22(1):64-71.
21. Callegari-Jacques SM. Bioestatística: princípios e aplicações. Porto Alegre (Brazil): Artemed; 2003.
22. Linares M, Contreras I, Cox PP, Burgos R, Lara J, Meyer R. Evaluación del rendimiento de la espirometría en preescolares sanos con estandarización adaptada a este grupo etario. *Rev Chil Enf Respir*. 2006;22(3):155-63.
23. Silva LCC, Rubin AS, Silva LMC, Fernandes JC. Espirometria na prática médica. *Rev AMRIGS*. 2005;49(3):183-94.
24. Mattiello R, Sarria EE, Stein R, Fischer GB, Mocelin HT, Barreto SS, et al. Functional capacity assessment in children and adolescents with post-infectious bronchiolitis obliterans. *J Pediatr (Rio J)*. 2008;84(4):337-43.

25. Morrow BM, Argent AC, Zar HJ, Westwood AT. Improvements in lung function of a pediatric cystic fibrosis population in a developing country. *J Pediatr (Rio J)*. 2008;84(5):403-9.
26. Chatkin MN, Menezes AM, Macedo SE, Fiss E. Asthma and lung function in a birth cohort at 6-7 years of age in southern Brazil. *J Bras Pneumol*. 2008;34(10):764-71.
27. Fiks IN, Santos LCA, Antunes T, Gonçalves RC, Carvalho CRF, Carvalho CRR. Frequência de sintomas de asma e de redução da função pulmonar entre crianças e adolescentes nadadores amadores. *J Bras Pneumol*. 2009;35(3):206-12.
28. Souza GAF, Faria ACD, Lopes AJ, Jansen JM, Costa E, Madeira I, et al. Avaliação do desempenho da técnica de oscilações forçadas na identificação precoce das alterações respiratórias em crianças asmáticas. *IFMBE Proceedings*. 2007;18(12):1005-9.
29. Eigen H, Bieler H, Grant D, Christoph K, Terrill D, Heilman DK, et al. Spirometric pulmonary function in healthy preschool children. *Am J Respir Crit Care Med*. 2001;163(3 Pt 1):619-23.
30. Cardoso AP, Oliveira MJR, Silva ÁMD, Águas AP, Pereira AS. Efeito da exposição prolongada a ruído ocupacional na função respiratória de trabalhadores da indústria têxtil. *Rev Port Pneumol*. 2006;12(1):45-60.
31. Díez JM, Asensi JRV, Vecchi AA. Resistências por oscilometria. Comparación de su comportamiento en pacientes con asma y fibrosis quística. *Rev Clin Esp*. 2006;206(2):95-7.
32. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet*. 2012;380(9838):219-29.
33. Tomalak W, Pogorzelski A, Prusak J. Normal values for maximal static inspiratory and expiratory pressures in healthy children. *Pediatr Pulmonol*. 2002;34(1):42-6.
34. Domènech-Clar R, López-Andreu JA, Compte-Torero L, Diego-Damiá A, Macián-Gisbert V, Perpiñá-Tordera M, et al. Maximal Static Respiratory Pressures in Children and Adolescents. *Pediatr Pulmonol*. 2003;35(2):126-32.
35. Joseph CLM, Ownby DR, Peterson EL, Johnson CC. Racial differences in physiologic parameters related to asthma among middle-class children. *Chest*. 2000;117(5):1336-44.
36. Frei J, Jutla J, Kramer G, Hatzakis GE, Ducharme FM, Davis GM. Impulse oscillometry: reference values in children 100 to 150 cm in height and 3 to 10 years of age. *Chest*. 2005;128(3):1266-73.
37. Silva CS, Torres LAGMM, Rahal A, Filho JT, Vianna EO. Avaliação de um programa de treinamento físico por quatro meses para crianças asmáticas. *J Bras Pneumol*. 2005;31(4):279-85.
38. Mendonça SL, Neto NCR, Vargas SC. Ginástica Respiratória Associada à Natação para Melhoria da Função Pulmonar em Crianças Portadoras de Asma Brônquica. *Saúde e Pesquisa*. 2010;3(3):291-6.
39. Schneiderman-Walker J, Pollock SL, Corey M, Wilkes DD, Canny GJ, Pedder L, et al. A randomized controlled trial of a 3-year home exercise program in cystic fibrosis. *J Pediatr*. 2000;136(3):304-10.
40. Klijn PH, Oudshoorn A, van der Ent CK, van der Net J, Kimpen JL, Helders PJ. Effects of anaerobic training in children with cystic fibrosis: a randomized controlled study. *Chest*. 2004;125(4):1299-305.
41. Chaves CRMM, Oliveira CQ, Britto JAA, Elsas MICG. Exercício aeróbico, treinamento de força muscular e testes de aptidão física para adolescentes com fibrose cística: revisão da literatura. *Rev Bras Saude Mater Infant*. 2007;7(3):245-50.

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