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# Association between EIB, anthropometry, quality of life and $VO_2$max in adolescents

*Relação entre BIE, antropometria, qualidade de vida e $VO_2$máx em adolescentes*

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**ABSTRACT**
The aim of the present study was to associate, using a cross-sectional design, exercise-induced bronchospasm (EIB), anthropometric profile, quality of life and cardiorespiratory fitness of adolescents. In order to do so, 202 subjects, aged 13 to 18 years, participated in the study. They underwent anthropometric measurements, a test to induce EIB, a cardiorespiratory test, and answered a questionnaire regarding their perception of quality of life. Data analysis was performed using descriptive statistics, group comparison (Student's T-test) and Pearson's Correlation. The level of significance was $p < 0.05$. Participants who did not present EIB showed significantly higher waist circumference values (72.02 ± 7.89 vs. 68.71 ± 6.65; p = 0.002). In addition, significant negative correlations were found between the percentage of decrease of the forced expiratory volume in the first second (FEV1), BMI (r = -0.138), waist circumference (r = -0.225), $VO_2$max (r = -0.144) and quality of life (r = -0.189).

**Keywords:** Adolescent. Anthropometry. Cardiorespiratory fitness. Exercise-induced bronchospasm. Quality of life.

**RESUMO**
Este estudo objetivou, por meio de um delineamento transversal, associar broncoespasmo induzido pelo exercício (BIE), perfil antropométrico, qualidade de vida e aptidão cardiorrespiratória de adolescentes. Para tanto, 202 sujeitos com idades entre 13 e 18 anos participaram da pesquisa. Eles foram submetidos a medidas antropométricas, teste de broncoprovocação, teste de aptidão cardiorrespiratória e responderam a um questionário de percepção de qualidade de vida. A análise dos dados ocorreu mediante análise descritiva, comparação entre grupos (Teste-T de *Student*) e Correlação de Pearson. O nível de significância foi $p < 0,05$. Os participantes que não apresentaram BIE obtiveram valores significativamente maiores para circunferência da cintura (72,02 ± 7,89 vs. 68,71 ± 6,65; p = 0,002). Observaram-se correlações significativas negativas entre percentual de queda do volume expiratório forçado no primeiro segundo (VEF1) e IMC (r = -0,138), circunferência da cintura (r = -0,225), $VO_2$máx (r = -0,144) e qualidade de vida (r = -0,189).

**Palavras-chave:** Adolescente. Antropometria. Aptidão cardiorrespiratória. Broncoespasmo induzido por exercício. Qualidade de vida.

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**INTRODUCTION**

Exercise-induced bronchospasm (EIB) is defined as a transient narrowing of the lower airways resulting from the practice of physical activity, manifesting itself clinically with symptoms such as coughing, wheezing, chest tightness and dyspnea[1]. The dominant stimulus in this process is hyperpnea caused by physical effort. This important mechanism is an association of cooling of the mucosa with an increase in bronchial interstitial osmolarity. The loss of water from the mucosa during physical activity increases the osmolarity of the periciliary fluid, leading to a release of chemical mediators, such as histamine, leukotrienes and prostaglandins. This can cause increased secretion production and airway tone, accompanied by hyperemia, edema and vascular congestion, resulting in bronchospasm[2].

The diagnosis of EIB occurs by examining the signs and symptoms reported by adolescents and the bronchial challenge test with exercise[3]. This test is performed by subjecting the individual to a physical activity that can be on a treadmill or stationary bicycle, as long as it reaches 80 to 90% maximum heart rate (HRmax) between six and eight minutes. Lung function is assessed before and after the tests by means of spirometry, and a reduction of more than 10% value of the forced expiratory volume in the first second (FEV1) baseline is considered as EIB[3].

This mechanism occurs more frequently among children and adolescents than in adults, with a prevalence that can be 7 to 19% in a general population of adolescents, occurring in the majority of individuals with asthma[4]: in individuals with asthma, it varies between 40 and 90 %, and in individuals with allergic rhinitis, between 10 and 40%[5].

Other important factors are overweight, physical inactivity and worsening of cardiorespiratory fitness[6]. Research has suggested that being overweight can increase the risk of respiratory disorders, as it leads to a systemic pro-inflammatory state and causes changes in ventilatory mechanics, generating bronchial hyperresponsiveness and thus decreasing tolerance to physical activity[7,8]. In this sense, the EIB, associated with the lack of exercise in adolescents, can increase the risk of psychosocial problems and poor school performance, making these individuals have a significantly worse quality of life (QOL)[9].

Although current evidence indicates strong functional and emotional impairment among patients with EIB, further studies are required to assess the behavior of this mechanism and QOL among individuals, with EIB objective measurements, in different populations and environments, to assist in promoting strategies that minimize the impacts caused by it. Thus, the objective of the present study was to analyze bronchospasm induced by exercise, anthropometric profile, quality of life and cardiorespiratory fitness of adolescents, and to verify whether the presence of this mechanism or not influences the other variables.

**METHODOLOGY**

STUDY DESIGN

This was a descriptive cross-sectional study.

SAMPLE AND ETHICAL ASPECTS

Students from a public school in the state of Pernambuco, randomly chosen, were invited to participate in this research. Considering that at the time of data collection there were 469 students enrolled, the equation for finite populations revealed the need for 212 people. All duly registered participants were invited to take part by means of notices in the classroom and the delivery of a written message together with the Informed Consent Form (ICF).

In all, 206 students returned the signed documentation and were included in the study. However, four participants were excluded during data collection for not having completed all stages of the study (three dropped out and one did not perform the PACER Test). Thus, 202 adolescents, aged between 13 and 18 years - of whom 94 (46.5%) were female and 108 (53.5%) were male - remained in the study. With the aid of the G*Power 3.0.10 software, the power of the analysis was calculated considering the statistical tests used. For the comparison of groups (Student's t-test) and Spearman's Correlation, taking into account an effect size of 0.44 and a margin of error of 5%, the power found was 0.90 and 0.99, respectively. Data were collected between February and June 2018.

The inclusion criteria in the study were: being in the 13 to 18 age group at the time of data collection; deliver the informed consent form signed by parents, guardians or by themselves (if over 18 years old); not having self-reported respiratory infection within four weeks prior to the test; not using bronchodilators before the bronchial challenge test with exercise to treat asthma or allergies; not having a history of cardiovascular and musculoskeletal diseases or being unable to exercise on a treadmill or running; and, in the case of those between 13 and 17 years old, sign the Informed Consent Form.

Adolescents who did not answer all questions in the Pediatric Quality of Life Inventory (PedsQLTM4.0) were excluded; who refused to indicate the maturity stage in which they were; and were opposed to performing the bronchial challenge test on the treadmill or the PACER Test.

This study was carried out in accordance with Resolution 466/12 of the National Health Council and approved by the Research Ethics Committee of the Federal University of São Francisco Valley (Univasf), under CAAE 80551417.5.0000.5196.

DATA COLLECTION

The collection took place in three stages: 1) anthropometric and maturity stage assessment; 2) spirometry, bronchial challenge test with exercise and assessment of quality of life using PedsQL™ 4.0; and 3) assessment of cardiorespiratory fitness through the application of the PACER Test. Steps 1 and 2 took place in February and March, and the PACER Test, between April and June. Anthropometric collections, assessment of the maturity stage and PedsQL™ 4.0 were performed individually in an empty classroom at the school, and the PACER Test, in turn, in the multi-sports court. Spirometry and bronchial challenge test with exercise were performed at the University of Pernambuco (UPE), in a closed and controlled environment, keeping the temperature between 20 °C and 25 °C and the air humidity below 50% through a digital hygrometer (Perception II, Davis®, Brazil).

The anthropometric assessment covered the following variables:

- Body mass: measured with a Wiso® digital scale (Santa Catarina, Brazil), accurate to 100 g; for this measurement, the volunteers wore light clothing and were barefoot.
- Height: measured with a portable Wiso® stadiometer (Santa Catarina, Brazil) accurate to 0.1 cm; during the measurement, the volunteers remained in an upright position, with heels, calves, buttocks, shoulders and head touching the wall - the position of the head followed the Frankfort plane, and the measurement was noted at the moment of inspiration.
- Body mass index (BMI): calculated from the division of body mass (in kilograms) by height (in meters) raised to the second power ($kg/m^2$). The classification of overweight and obesity was according to the z-score of BMI by age and sex[10]. In this, volunteers with values between +1.00 and +1.99 were considered overweight, while values above +2.00 characterized obesity.
- Waist circumference: measured with an inextensible measuring tape accurate to

0.1 cm (Cescorf®) at the midpoint between the last rib and the iliac crest.

The maturity stage was assessed using the Tanner's scale[11,12], a tool widely used to self-assess this condition in children and adolescents. In this, the volunteers looked at illustrative drawings of the male and female sexual organ and indicated which stage they were in (from 1 to 5). Next to each illustration, there was a brief description of the events expected for each phase, such as the appearance of pubic hair, growth and darkening of the scrotum and enlargement of the penis (for males) and breasts (for females). According to Campisi et al.[13], the self-reference of the maturity stage in adolescents is reliable especially in the post-pubertal period, corresponding to the age group of the present study.

Cardiorespiratory fitness was estimated based on the PACER Test, which is a multi-stage test and adapted from the 20-meter Shuttle Run test published by Leger and Lambert[14] and revised in 1988[15]. It consists of running a 20-meter course, going and returning, following a sound signal ("beep"), recorded in audio. At each "beep", the participant must complete the 20-meter shuttle. The test starts at a slow speed, and every minute the interval between the "beeps" decreases, causing the participants to increase their pace; it ends when the person is unable to follow the sound signal twice in a row[16].

Based on the data obtained in the PACER Test, the cardiorespiratory fitness ($VO_2max$) of participants was estimated from the equation proposed by Boiarskaia et al.[17]. This takes into account the number of shuttles performed (20-meter shuttles), the sex and age of the participant, as follows: $VO_2máx = 32.57 + 0.27 \times (\text{number of shuttles}) + 3.25 \times (\text{sex}) + 0.03 \times (\text{age})$; it is worth mentioning that the female gender corresponds to zero, and the male, the value 1.

Bronchial hyperresponsiveness, in turn, was analyzed using the bronchial challenge test with exercise, which was performed by a trained and qualified team. To assess lung function, participants were instructed not to drink coffee, tea or soda with caffeine two hours before, not to use short and long-acting bronchodilators 12 hours before, and to suspend short and long-term antihistamines, respectively, 48 hours and the five days preceding the exam. Adolescents also could not have symptoms of viral infection of the upper airway in the last four weeks.

Pulmonary function parameter evaluated was FEV1 before and after exercise using a spirometer (Cosmed®, microQuark, Italy). The individual remained sat with a nose clip and performed three breathing maneuvers in the spirometer; the one with the highest FEV1 value was selected for age, sex, height and weight, based on Polgar et al.[18]. The pulmonary function, after the test, was analyzed using FEV1, in liters, at 5, 10, 15 and 20 minutes after physical exercise. EIB was considered positive when there was a reduction in FEV1 $\geq$ 10% when compared to the pre-exercise value[1]. The physical exercise was performed on a treadmill (Inbramed®, Master Super ATL, Brazil), with an intensity equal to or greater than 85% of the maximum heart rate monitored by a heart rate monitor (Polar® Electro Oy, Finland).

Finally, the quality of life of adolescents was assessed using the Pediatric Quality of Life Inventory (PedsQL™ 4.0), developed by Varni et al.[19] and validated for Brazil by Klatchoian et al.[20]. The generic PedsQL™ 4.0 questionnaire, which includes self-assessment forms for adolescents (13-18 years), consists of 23 questions divided into four dimensions: physical functioning (eight items), emotional functioning (five items), social functioning (five items) and school functioning (five items). Questions are scored from 0 (never a problem) to 4 (almost always a problem). This score is converted into a scale from 0 to 100 (0 = 100, 1 = 75, 2 = 50, 3 = 25, 4 = 0); higher scores reveal better quality of life. Finally, adding the items of each dimension (on a 0-100 scale) and dividing by the number of items that each contains, the value of specific quality of life for each dimension is obtained. Adding the values of the four dimensions and dividing them by four, the value of overall quality of life is obtained. It is still possible to obtain the psychosocial total, adding the scores of the dimensions of emotional, social and school functioning and dividing them by three.

STATISTICAL ANALYSIS

After collection, data were transferred to the Statistical Package for the Social Sciences (SPSS), version 22.0 for Windows®, through which they were analyzed. Outliers in the database were corrected by adding a unit to the extreme value for each variable[21]. This is performed with the visual aid of the graphic of stem and leaves. Thus, if a participant had a BMI of 37.00 kg/m² and the graph of stem and leaves indicated that BMI values above 30.00 kg/m² were considered extreme, that participant's BMI was changed to 31.00 kg/m². In this procedure, the value remains considered an outlier, but its distance from the mean value becomes smaller.

Then, normality was assessed by asymmetry, respecting the interval between -1.00 and +1.00, and by the Kolmogorov-Smirnov test. Once this was confirmed, a descriptive analysis was performed on the data, which are expressed as mean, standard deviation, absolute frequency (n) and relative frequency (%). The Student's t-test for independent measures was performed to compare the groups according to the aforementioned classifications. Cohen's d was calculated to check the magnitude of the analysis effect. In addition, a Pearson Correlation was applied to identify the association between variables. The level of significance was set at $p < 0.05$.

## RESULTS

Regarding BMI, 13 participants (6.4%) were considered thin, 156 (77.2%) eutrophic, 19 (9.4%) overweight and 14 (6.9%) obese. In the EIB classification, 133 (65.8%) had negative results, 50 (24.8%) had mild EIB, 18 (8.9%) moderate and 1 (0.5%) severe. Grouping the EIB into absence and presence, 133 (65.8%) did not present it, and in 69 (34.2%) there was evidence. As for cardiorespiratory fitness, the findings revealed that in 128 (63.4%) it was low, and in 74 (36.6%), it was adequate.

As to the controlled and closed environment where the bronchial challenge test with exercise and spirometry was performed, the average temperature was 24.82 °C (± 1.34), and the relative humidity, 61.12% (± 5.52). The mean heart rate (HR) during the test was 170.10 bpm (± 4.88), and the subjective perception of effort, assessed by the Borg scale, 9.95 (± 1.98).

Table 1 shows the general characteristics of the study participants with regard to age, anthropometric variables, maturity stage, drop in FEV1, cardiorespiratory fitness and quality of life (QOL) domains

**Table 1.** general characteristics of the sample (n = 202)

| | Mean ± standard deviation |
|---|---|
| Age (years) | 14.97 ± 1.31 |
| Body mass (kg) | 56.98 ± 11.33 |
| Height (m) | 1.67 ± 0.09 |
| Body mass index (kg/m²) | 20.30 ± 3.31 |
| Waist circumference (cm) | 70.89 ± 7.63 |
| Puberty stage | 4.07 ± 0.83 |
| Drop in FEV1 (%) | 8.75 ± 10.21 |
| $VO_2$max (mL/kg/min) | 43.69 ± 6.63 |
| QOL Physical domain | 76.41 ± 14.63 |
| QOL Psychosocial domain | 70.18 ± 14.98 |
| Overall QOL | 71.74 ± 13.86 |

**Legend:** FEV1 = forced expiratory volume in the 1st second; $VO_2$max = maximum oxygen consumption; QOL = quality of life.

Source: Research data.

Table 2 lists the comparison between the anthropometric variables, cardiorespiratory fitness, level of physical activity and QOL domains regarding the absence or presence of EIB of the participants. In this scenario, the t-test for independent samples evidenced significant differences for body mass, height and waist circumference, in which those with no EIB presented significantly higher values of body mass (p = 0.002; *d* = 0.45), height (p = 0.007; *d* = 0.44) and waist circumference (p = 0.002; *d* = 0.45) than those in which EIB was found, with an effect size considered medium.

**Table 2.** Comparisons of anthropometric variables, cardiorespiratory fitness and QOL domains according to the absence or presence of EIB (n = 202). Data expressed as mean ± standard deviation

| | **Absence (n=133)** | **Presence (n=69)** | **p-value** | ***Effect size*** |
|---|---|---|---|---|
| BMI (kg/m²) | 20.59 ± 3.50 | 19.74 ± 2.85 | 0.066 | 0.27 |
| Waist (cm) | 72.02 ± 7.89 | 68.71 ± 6.65 | **0.002*** | 0.45 |
| $VO_2$max (mL/kg/min) | 44.26 ± 6.97 | 42.57 ± 5.81 | 0.069 | 0.26 |
| QOL Physical domain | 77.70 ± 15.20 | 73.91 ± 13.21 | 0.081 | 0.27 |
| QOL Psychosocial domain | 70.84 ± 15.14 | 68.91 ± 14.69 | 0.387 | 0.13 |
| Overall QOL | 72.55 ± 14.20 | 70.16 ± 13.12 | 0.246 | 0.17 |

**Legend**: BMI = body mass index; Waist = waist circumference; $VO_2$max = maximum oxygen consumption; QOL = quality of life. * $p < 0.05$.

Source: Research data.

Table 3, in turn, shows the significant Pearson correlation between the percentage of FEV1 drop and the other variables studied. In this sense, it was possible to observe significant negative correlations between the variables, demonstrating that the higher this percentage, the lower the values of anthropometric variables, cardiorespiratory fitness and perception of quality of life.

**Table 3.** Pearson correlation between the percentage of FEV1 drop and anthropometric profile, cardiorespiratory fitness and perception of quality of life

| | **BMI** | **Waist** | **$VO_2$max** | **Physical QOL** | **Psychosocial QOL** | **Overall QOL** |
|---|---|---|---|---|---|---|
| **FEV1** | -0.138* | -0.225* | -0.144* | -0.218** | -0.211** | -0.189** |

**Legend:** BMI = body mass index; Waist = waist circumference; $VO_2$max = maximum oxygen consumption; QOL = quality of life. * $p < 0.05$.

Source: Research data.

**DISCUSSION**

In the present study, adolescents who did not have EIB had greater body mass, height and waist circumference when compared to adolescents with EIB. This finding confronts some studies available in the literature that observed a higher frequency of EIB in overweight or obese individuals[22-23]. Research by Silva et al.[22] recruited children and adolescents between 8 and 15 years of age from the Nutrition Department of the Hospital de Clínicas of the Federal University of Uberlândia (UFU) to assess the risk factors associated with EIB among those without a previous diagnosis of asthma through spirometric parameters. The authors observed that children and adolescents with excess body mass have a greater association with the occurrence of EIB.

In another study conducted in the city of Petrolina (state of Pernambuco), Costa et al.[23] evaluated the effects of overweight on spirometric parameters of adolescents undergoing exercise. The sample consisted of 71 individuals from 12 to 16 years old divided into two groups: GEP (overweight group) and GE (eutrophic group). The authors found a maximum FEV1 drop significantly greater in GEP than in GE, and a higher frequency of EIB in GEP, indicating that the accumulation of adipose tissue can be considered a predisposing factor for triggering EIB. This was not observed in the present study, which can be because the sample is composed of more individuals with normal BMI than with high BMI (169 versus 33, respectively).

Excess weight may be related to changes in the respiratory system, in which the accumulation of adipose tissue in the region around the chest wall can lead to changes in lung mechanics, reduced lung volumes and capacities[22-24]. In addition, adipose cells produce inflammatory mediators that have the potential to change and can modify the airway response and generate a greater probability of developing BIE[25].

Considering the occurrence of EIB, 133 (65.8%) adolescents who participated in this study did not present EIB, and in 69 (34.2%), it was evidenced. This predominance was shown to be greater than that found by Johansson et al.[5], who investigated the prevalence of EIB in a general population of adolescents and verified that it is estimated at 19.2% in this group, with no gender differences. One of the possible causes of greater occurrence perceived in the present study when compared to others may be due to the fact that the region where the research was developed has a dry climate, in which individuals may present increased dehydration of the airway mucosa in comparison to other locations with a more humid climate. This can generate a stronger response by inflammatory cells, releasing mediators capable of resulting in a higher occurrence of bronchospasm[26].

The respiratory symptoms caused by EIB can restrict the individual's ability to be physically active, causing negative health effects, as physical exercise is associated with numerous benefits. Besides activity limitations, damage to daily life, such as sleep disorders, absence from school and hospitalization, can occur[5]. Some evidence suggests that children and adolescents who regularly participate in physical activity programs are more likely to report a better quality of life than those who have never been involved with such initiatives[27].

In this sense, although no significant differences were detected in cardiorespiratory fitness between participants with the presence or absence of EIB, Pearson's Correlation showed a negative association between the $VO_2max$ estimated by the PACER Test and the percentage of FEV1 drop, inferring that the greater this drop, the lower the participant's cardiorespiratory fitness. Furthermore, it is known that individuals who trigger EIB have difficulty adhering to physical activity programs, due to the exacerbation of symptoms and discomfort in the respiratory tract[28].

In the present study, differences in the perception of QOL between adolescents with and without EIB did not occur. This is in line with Kock et al.[29], who identified a significant difference only in the domain of overall QOL, in which the group with no EIB obtained higher scores. Johansson et al.[4] did not perceive significant differences in the psychosocial domain of QOL between adolescents with and without EIB, as well as they did not find them among female and male adolescents.

Nevertheless, in the same way as cardiorespiratory fitness, there were also significant negative correlations between the percentage of FEV1 drop and the participants' perception of QOL, indicating a relationship between the variables, although weak. In this sense, Johansson et al.[4] suggest that individuals with EIB may experience symptoms of anxiety, lower lung function and greater propensity to sleep disorders more frequently, impairing the perception of quality of life.

EIB can lead to a substantial emotional burden on individuals and restrict the practice of exercise and sports, which potentially leads to long-term consequences on the quality of life and physical health of these people. An important strategy in this process is the awareness of patients and health professionals about the symptoms and risk factors for EIB, in addition to an increase in the application of diagnostic tests. These measures are the key to the management of patients with EIB in order to encourage strategies that minimize the impacts caused[30].

The present study brings important results, such as the significant negative correlation between the percentage of FEV1 drop and the variables studied, even though there are controversial results regarding the anthropometric profile. However, it is worth noting that there are limitations such as: the cross-sectional nature of the study, which did not allow establishing a cause-effect relationship between the studied phenomena; and the discrepancy between the number of participants with and without EIB, which may have interfered with the results (such as BMI and waist circumference, for example).

## CONCLUSION

The present study observed significant differences in waist circumference when comparing adolescents with and without EIB, with statistically higher values among those without EIB. In addition, significant negative correlations were reported between the percentage of FEV1 drop and all the variables studied, indicating a negative relationship of FEV1 also with cardiorespiratory fitness and students' perception of quality of life. Thus, it can be inferred that there is a relationship between EIB and anthropometric variables, cardiorespiratory fitness and quality of life of adolescents.

## REFERENCES

1. Parsons JP, Hallstrand TS, Mastronarde JG, Kaminsky DA, Rundell KW, Hull JH, et al. An Official American Thoracic Society Clinical Practice Guideline: Exercise-induced Bronchoconstriction. Am J Respir Crit Care Med. 2013;187(9):1016-27.

2. Borak J, Lefkowitz RY. Bronchial hyperresponsiveness. Occupational Medicine. 2016;66:95-105.

3. Anderson SD Kippelen P. Assessment of EIB: what you need to know to optimize test results. Immunol Allergy Clin N Am. 2013;33:363-80.

4. Johansson H, Norlander K, Janson C, Malinovschi A, Nordang L, Emtner M. The relationship between exercise induced bronchial obstruction and health related quality of life in female and male adolescents from a general population. BMC Pulmonary Medicine. 2016;16:63.

5. Johansson H, Norlander K, Hedenström H, Janson C, Nordang L, Nordvall L, et al. Exercise-induced dyspnea is a problem among the general adolescent population. Respir Med. 2014;108:852-8.

6. Farah BQ, Christofaro DGD, Balagopal PB, Cavalcante BR, Barros MVG, Ritti-Dias RM. Association between resting heart rate and cardiovascular risk factors in adolescents. Eur J Ped. 2015;174(12):1621-28.

7. Cieslak F, Lopes WA, Lazarotto L, Timossi LS,

Leite N. Parâmetros fisiológicos em adolescentes obesos asmáticos e não asmáticos submetidos ao broncoespasmo induzido pelo exercício. Motricidade. 2012;8(2):555-66.

8. Cieslak F, Rosário Filho NA, Titski ACK, Timossi LS, Dias R, Calixto AR, et al. Adiponectinemia e indicadores fisiológicos em adolescentes obesos asmáticos e não asmáticos. Medicina (Ribeirão Preto). 2013;46(4):404-15.

9. Basso RP, Jamami M, Labadessa IG, Regueiro EMG, Pessoa BV, Oliveira Jr AD, et al. Relação da capacidade de exercício com a qualidade de vida de adolescentes asmáticos. J Bras Pneumol. 2013;39(2):121-7.

10. World Health Organization. Growth reference 5-19 years [Internet]. [S.d.] [cited in 2018 Oct 10]. Available in: http://www.who.int/growthref/who2007_bmi_for_age/en/

11. Marshall WA, Tanner JM. Variations in the pattern of pubertal changes in boys. Arch Dis Child. 1970;45:13-23.

12. Marshall WA, Tanner JM. Variations in pattern of pubertal changes in girls. Arch Dis Child. 1969;44(235):291-303.

13. Campisi SC, Marchand JD, Siddiqui FJ, Islam M, Bhutta ZA, Palmert MR. Can we rely on adolescents to self-assess puberty stage? A systemic review and meta-analysis. J Clin Endocrinol Metab. 2020;105(8):2846-56.

14. Leger LA, Lambert J. A maximal multistage 20-m shuttle run test to predict VO2max. Eur J Applied Physiology and Occupational Physiology. 1982;49:1-12.

15. Leger LA, Mercier D, Gadoury C, Lambert J. The multistage 20 meter shuttle run test for aerobic fitness. J Sports Sciences. 1988;6:93-101.

16. Plowman SA, Meredith MD. Fitnessgram/Activitygram Reference Guide. 4th edition. Dallas, TX: The Cooper Institute; 2013.

17. Boiarskaia EA, Boscolo MS, Zhu W, Mahar MT. Cross-validation of an equating method linking aerobic FITNESSGRAM® field tests. Am J Prev Med. 2011;41(4):S124-S130.

18. Polgar G, Promodhat V. Pulmonary function testing in children: techniques and standards. Philadelphia: WB Saunders; 1971.

19. Varni J, Burwinkle T, Seid M, Skarr D. The PedsQL 4.0 as a Pediatric Population Health Measure: Feasibility, Reliability, and Validity. Ambul Pediatr. 2003;3(6):329-41.

20. Klatchoian DA, Len CA, Terreri MTRA Silva M, Itamoto C, Ciconelli RM, et al. Quality of life of children and adolescents from São Paulo: reliability and validity of the Brazilian version of the Pediatric Quality of Life Inventory™ version 4.0 Generic Core Scales. J Pediatr. 2008;84(4). doi: http://dx.doi.org/10.1590/S0021-75572008000400005

21. Field A. Descobrindo a estatística usando o SPSS. 2ª ed. Porto Alegre: Artmed; 2009.

22. Silva LO, Silva PL, Silva MB, Cheik N. Avaliação dos fatores de risco associados ao broncoespasmo induzido pelo exercício em crianças e adolescentes sem diagnóstico prévio de asma. Arq Asma Alerg Imunol. 2017;1(4):387-94.

23. Costa RO, Silva JP, Lacerda EM, Dias R, Pezolato VA, Silva CA, et al. Overweight effect on spirometric parameters in adolescents undergoing exercise. Einstein. 2016;14(2):190-5.

24. Barros R, Moreira P, Padrão P, Teixeira VH, Carvalho P, Delgado L, et al. Obesity increases the prevalence and the incidence of asthma and worsens asthma severity. Clin Nutr. 2017;36:1068-74.

25. Lang JE. Exercise, obesity, and asthma in children and adolescents. J Pediatr. 2014;90(3):215-17.

26. Correia MAV Junior, Costa EC, Sarinho SW, Rizzo JA, Sarinho ESC. Exercise-induced bronchospasm in a hot and dry region: study of asthmatic, rhinitistic and asymptomatic adolescents. Expert Review of Respiratory Medicine. 2017; 11(12):1013-19.

27. Gopinath B, Hardy LL, Baur LA, Burlutsky G, Mitchell P. Physical activity and sedentary behaviors and health-related quality of life in

adolescents. Pediatrics. 2012; 130(1):e167-74. doi: https://doi.org/10.1542/peds.2011-3637
28. Minic PB, Sovtic AD. Exercise intolerance and exercise-induced bronchoconstriction in children. Frontiers in Bioscience. 2017;9:21-32.

29. Kock KS, Wolter AP, Tomé SV, Huber MP, Silva J. Qualidade de vida em adolescentes com broncoespasmo induzido pelo esforço. Rev Ciênc Méd Biol. 2014; 13(2):212-19.

30. Aggarwal B, Mulgirigama A, Berend N. Exercise-induced bronchoconstriction: prevalence, pathophysiology, patient impact, diagnosis and management. Primary Care Respiratory Medicine. 2018;28(1):31. doi: https://doi.org/10.1038/s41533-018-0098-2.