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EDITORIAL

Exercise, obesity, and asthma in children and adolescents☆,☆☆

Exercício, obesidade e asma em crianças e adolescentes

Jason E. Lang[a,b]

[a] *Division of Pulmonary and Sleep Medicine, Nemours Children's Hospital, Orlando, United States*
[b] *Center for Pharmacogenomics & Translational Research, Nemours Children's Clinic, Jacksonville, United States*

Overweight has become increasingly common in children around the world. Unfortunately, Brazil is no exception.[1] Additionally, due to increased access to many modern conveniences, the physical activity levels in this age group have declined. Besides metabolic sequelae, obesity combined with a sedentary activity level can also negatively affect multiple organ systems throughout the body. Data are accumulating which indicate that the respiratory system is not an exception. Respiratory symptoms are a leading reason for pediatric consultations. The effects of weight gain and a sedentary lifestyle may be playing a larger role in lung disease than ever.

Obesity has been repeatedly associated with an increased risk of developing new cases of objectively and rigorously defined asthma.[2–4] Also, it has been difficult to define the ways through which obesity affects the asthma phenotype in children and adolescents. Two of the most consistent phenotypic findings specific to children with obese asthma are (1) greater symptom burden and (2) reduced response to daily inhaled corticosteroids. There is now some evidence that weight loss among obese asthmatic children improves asthma-related outcomes.[5] However, relatively little data exist on the effects of exercise and exercise capacity in children with children with asthma or obesity. Obesity in otherwise healthy (non-asthmatic) adults negatively affects lung functioning, while less is known about how obesity and exercise affect the developing respiratory tract in a child. The relationships between exercise, obesity, and asthma are examined in two interesting studies by de Andrade et al.[6] and Faria et al.[7] in this issue of Jornal de Pediatria.

Faria et al.[7] were interested in testing the lung function and physical activity of obese adolescents not yet with diagnosed respiratory problems. Obesity, especially in adults with a body mass index (BMI) above 35 kg/m^2, has been associated with chest restriction; reduced total lung capacity, functional residual capacity, and expiratory reserve capacity; and greater residual volume.[8] Pulmonary mechanics have not been studied as extensively in children and have not been consistent. It is likely that the relationship between obesity and lung outcomes vary based on other factors such as age, gender, activity level, and age-of-onset of obesity. Among school-aged children, obesity has been associated with increased breathlessness and cough,[9] and increased exercise-induced bronchospasm.[10] In pre-pubertal children, there is not a clear association between obesity status and lung function parameters.[9,11,12] Gender may be an important third factor affecting the relationship between obesity and lung function. Early life obesity, particularly in boys, may reduce lung growth. There is some evidence in young boys that obesity associates with airflow obstruction (measured by FEV1/FVC).[12] We have found similar airflow impairment among young boys with asthma,[13] but the interaction between obesity and gender in children requires further study.

In adolescents, the relationship between obesity and lung function is more similar to that observed in adults. Otherwise healthy obese adolescents have variably reduced

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E-mail: jason.lang@nemours.org

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residual volumes and functional residual capacity (on account of chest restriction) and impaired diffusion capacity.[14] Obese adolescents have shown airflow obstruction less commonly compared to younger children. However, like younger children, obese adolescents are more likely to display exercise-induced bronchospasm (EIB).[15,16] The exact mechanism causing this reported obesity-related EIB requires further exploration. Furthermore, the cardiopulmonary responses to exercise have rarely been performed in children with a focus on the influence of obesity. Since simple obesity is a risk factor for the development of new-onset asthma symptoms and asthma diagnosis, examining respiratory outcomes in a cohort of obese children 'at-risk' for asthma (on account of their obese state) may provide clues regarding the connection between obesity and asthma.

Faria et al.[7] enrolled 92 children between the ages of 10 and 17 without prior lung disease from the Pediatric Obesity Clinic of the Hospital Universitário da Universidade Estadual de Campinas (Unicamp), Campinas, Brazil to test the effect of obesity and gender on lung responses to exercise. The authors defined obesity as a BMI > 95th percentile using the World Health Organization reference curve. Body composition (body fat and lean mass) was also assessed by bioelectrical impedance analysis. Respiratory muscle strength and spirometric lung volumes were measured before and after exercise using standard procedures. The exercise challenge and follow-up lung function testing adhered to accepted conventions of the European Respiratory and American Thoracic Societies.

The authors analyzed the results using four similarly sized groups based on gender and obesity status. Baseline blood pressure and heart rate were higher in the obese groups regardless of gender and these elevations continued with exercise. Baseline lung function was associated with gender; males displayed increased FVC and FEV1. Importantly, the effect of obesity on lung function appeared to depend on gender. In girls, obesity was associated with similar or improved FVC and FEV1, while in boys obesity was associated with reduced values. This interaction between obesity and gender on lung function continued post-exercise. Generally, obese boys and girls tolerated exercise well, and post-exercise drops in lung function did not appear to be greater among the obese compared to eutrophic children.

Maximal inspiratory pressure (MIP) and expiratory pressure (MEP) were measured as a representation of respiratory muscle power. MIP reflects the acute strength of the diaphragm and accessory inspiratory muscles, while MEP reflects the acute strength of the abdominal and accessory expiratory muscles. It is important to note that MIP and MEP may not fully detect the respiratory system's propensity for fatigue. Obese males in this study had higher, not lower, maximal inspiratory and expiratory pressures compared to eutrophic males, suggesting obesity may be associated with additional lean respiratory muscle mass and power.

Maximal voluntary ventilation (MVV) was also measured. It can be used to estimate ventilatory reserves available to meet the physiologic demands of exercise and would be able to better detect respiratory muscle endurance and the propensity for muscle fatigue. Faria et al. observed that boys had higher MVV than girls. Interestingly, in both genders, obesity was associated with an MVV that was substantially diminished before and after exercise. A notable result was that among females (obese or eutrophic), exercise did not reduce MVV. In other words, exercise did not appear to exhaust the respiratory reserve of girls. However, in boys (particularly those who were obese), MVV diminished with exercise. These results will need to be replicated in larger studies with adjustments for age and other potential confounders, but suggest that obesity in boys may lead to higher peak respiratory muscle power but at the cost of greater respiratory muscle fatigue.

The etiology of these gender differences was not specifically examined in the study, however, the authors rightly state that differential fat distribution and altered baseline respiratory mechanics may play a role. Obesity-related reductions in expiratory reserve volume (ERV) that were diminished in both obese genders may be more impactful in boys. However, the reasons are unclear. Although the truncal obesity (fat storage in the chest and abdomen) is more common in adult males (compared to adult females), this same gender pattern is not as consistent in children. Future studies that measure the effect of fat distribution on lung function are needed. Even though this effect is more pronounced in boys, obesity is associated with poorer lung function and reduced ventilatory reserve in both genders. With this degree of obesity-related ventilatory impairment, many obese children would be expected to adopt a more sedentary lifestyle. Despite the fact that this study did not specifically adjust for this factor, it is possible that reduced physical activity may mediate the association between obesity status and impaired lung and ventilatory function.

In the current issue of the Journal, a separate group of investigators studied the effects of asthma, activity level, and obesity status on exercise performance. In the study by de Andrade et al.,[6] the investigators enrolled 40 children between the ages of 6 and 16 years each with physician-diagnosed asthma. 29 of the children had a normal BMI, while 12 had a BMI in the overweight range. Participants were recruited from the outpatient pediatric pulmonology and respiratory physical therapy clinic from the Instituto de Medicina Integral Professor Fernando Figueira (IMIP), Brazil. Participants had moderate and severe persistent asthma, defined according to the IV Brazilian guidelines for the management of asthma, and were clinically stable and otherwise healthy. Participants underwent baseline evaluations including questionnaires to assess asthma control, quality of life, and routine level of physical activity determined by the habitual level of physical activity questionnaire by Santuz.[17] Baseline spirometry and a six-minute walk test (6MWT) were performed per ATS/ERS standards. Vital signs, oxygen saturation, and dyspnea index (Borg scale) were monitoring during and after the 6MWT. Results were compared to reference values for age-, height- and weight-matched healthy Brazilian children.[18]

The cohort was 48% female and had a mean age of 11.3 years. 30% were obese and 70% met the definition for sedentary activity level. Using Brazilian asthma guidelines, the investigators determined that 65% and 35% had severe and moderate asthma, respectively. All participants were being prescribed at least a low-dose of daily inhaled corticosteroids (ICS), and 60% were on a combination of ICS and long-acting beta-agonists.

The results of the study showed the mean distance achieved on the 6MWT was 430 meters, 170 meters below the expected mean for the group, an average of only 71% of the expected value. Clearly, having asthma (or conditions related to asthma) appears to substantially impair cardiopulmonary performance. Interestingly, the characteristics of gender, asthma severity, obesity status, and controller medication intensity were all not associated with 6MWT distance. Importantly, the only factor that was associated with 6MWT distance was the child's baseline level of activity. When the investigators took into account the predicted distances, they found that age was inversely associated with 6MWT percent predicted. As children advance into adolescence, many adopt a sedentary level of activity, which is consistent with the results from de Andrade et al.[6] More research is needed to determine the mechanism of the association between activity level and asthma-related outcomes. Confounding factors to activity level may be playing a partial role that must be explored in future studies. An example is that daily activity level may be associated with asthma controller adherence, with the latter factor leading to improved 6MWT distance. Future studies that directly compare exercise capacity in asthmatic *versus* non-asthmatic children and that are large enough to statistically adjust for multiple confounders will be needed in order to further confirm the importance of activity level in asthma-related outcomes.

Regardless, de Andrade et al.[6] give us a remarkable set of results that constitutes an important public health message. Children with asthma should not shy away from daily exercise. The authors rightly point out that asthma is associated with reduced activity, which may stem from families' concerns about exercise-related asthma attacks. However, health care providers must teach families at every opportunity that the goal of asthma control is achieving a lifestyle that allows for daily physical exercise. Additionally, parents and adolescents need to be taught that routine exercise will improve asthma-related quality of life and may make persistent asthma easier to control in the long run.

Faria et al.[7] and de Andrade et al.[6] together deserve credit for performing research in an understudied but critically important field of pediatric health. As with all good science, these studies create more new questions than answers. The work by Faria et al.[7] challenges future scientists to answer why obesity particularly impairs boys and their ventilatory reserve. The study by de Andrade et al.[6] invites further exploration of the precise mechanisms connecting daily activity and asthma severity. Pediatricians know that healthy breathing is a top concern to parents, and they have always known that avoiding obesity and maintaining daily exercise are important for children to grow up with healthy lungs. Future studies will tell us more about why.

Conflicts of interest

The author declares no conflicts of interest.

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