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Impulse Oscillometry and Exercise Bronchoconstriction in Children and Adolescents

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ABSTRACT

The gold standard for diagnosing exercise-induced obstruction in children is a drop in FEV1 ≥ 10% after vigorous physical activity. Not all children can achieve the exercise challenge test. In this scenario, Impulse Oscillometry emerges as an alternative method. A review of the available evidence for the use of IOS in the diagnosis of EIB was performed. In preschool IOS, the increase of ≥ 35-40% in resistance at 5 Hertz after free running exercise has proven to be a good parameter. In children and adolescents, the cut-off points for raising R5 have been shown to be lower, but with a good negative predictive value to rule out EIB. In this group, it could also be useful to measure within-breath differences in reactance.

Keywords: Preschoolers; Children; Adolescents; Exercise-Induced Bronchial Obstruction; Impulse Oscillometry

Introduction

Exercise-induced bronchoconstriction (EIB) is defined as the transient and reversible narrowing of the lower airways that appears with physical exercise, which can occur in the presence or absence of bronchial asthma [1]. In children over 6 years of age, EIB is confirmed with the exercise challenge test (ECT) that measures the values of forced expiratory flow in the first second (FEV1) at 3, 5, 10, 15, and 30 minutes after at least 6 minutes vigorous exercise on a treadmill or cycle ergometer. A decrease equal to or greater than 10% in FEV1 compared to the baseline value before exercise confirms EIB [2]. Figure 1 shows an example of a traditional exercise challenge test with FEV1. Children under 6 years of age have shorter expiratory times and less ability to perform conventional ECT. In this group of children, it has been recommended to perform ECT after a free run and use the forced expiratory volume at 0.5 seconds (FEV 0.5). A 13% drop in FEV 0.5 ha has been proposed to consider BIE in preschoolers aged 3 to 6 years who perform spirometry [3]. The spirometric maneuver is effort-dependent and requires important cooperation on the part of the patient, who must inhale at maximum capacity and exhale with the greatest force and duration possible. On the contrary, Impulse oscillometry (IOS) only requires minimal effort to perform inspirations and expirations, since they are performed at tidal volume. It has been shown that only 80% of children can perform the forced spirometric maneuver, a percentage that decreases at a younger age, unlike 100% of children who are able to perform the IOS even from 2 to 3 years old [4]. The purpose of this mini-review is to review available evidence for the use of IOS in the diagnosis of EIB.

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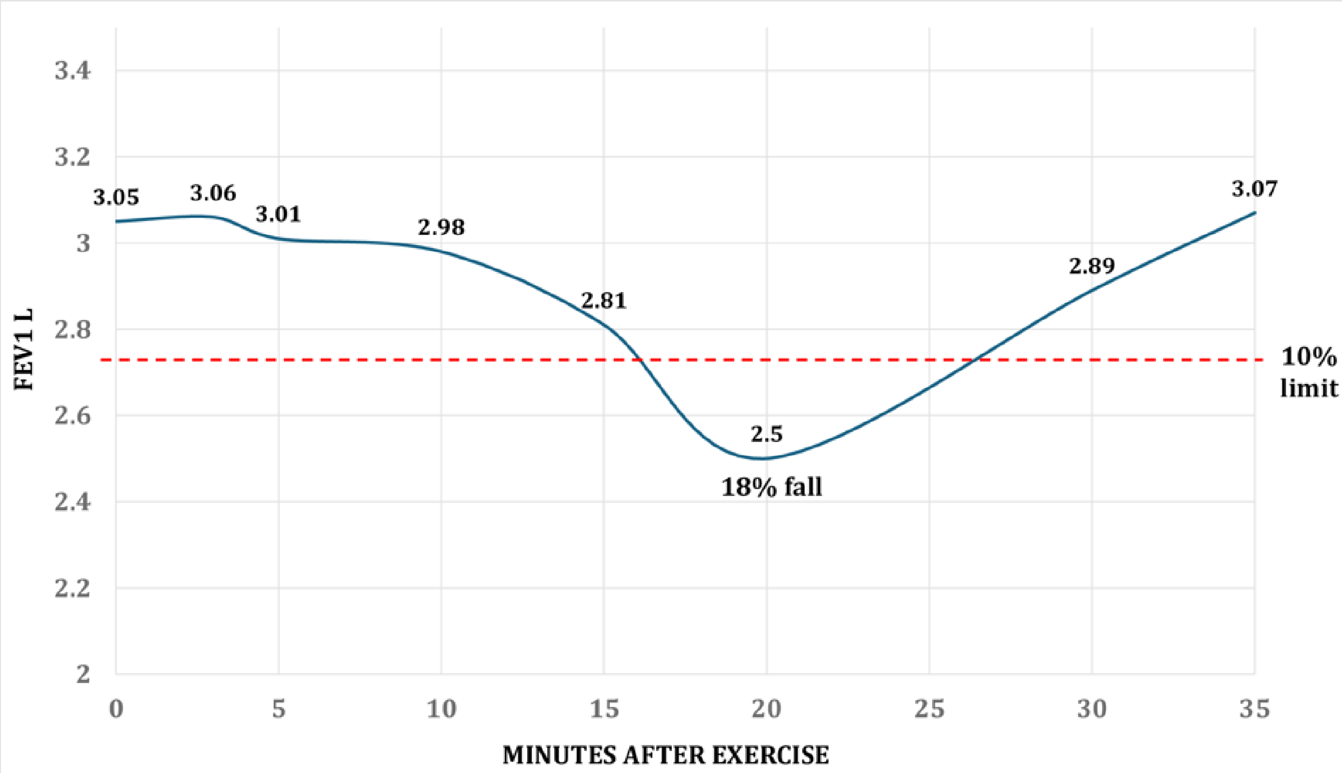

Figure 1: Positive exercise challenge test. A 12-year-old adolescent who suffers a decrease of 18% in FEV1 at 20 minutes after exercise. The value at 35 minutes is after bronchodilation.

Methods

A review of the evidence was carried out scientific study on the use of IOS in the diagnosis of exercise-induced bronchoconstriction. The search for articles was carried out between January and February 2024 in the databases Medline (PubMed), Web of Science (WOS), EBSCO Host, Science Direct, and SCOPUS. MeSH terms and free terms in their English version were used. The terms were grouped into two dimensions:

i) Impulse oscillometry

ii) Exercise-induced bronchial obstruction. The boolean operator was used "and '' to integrate the two dimensions.

The articles found were grouped into two categories by age range:

1) Preschoolers

2) Children and adolescents.

Preschoolers

A study carried out with children from 3 to 7 years old who underwent a free run of 6-8 minutes followed by measurement of IOS parameters at 2, 5, and 10 minutes after exercise, demonstrated that those who had a history of wheezing in the last 12 months showed changes in resistance at 5 Hertz (R5), in the reactance at 5 Hertz (X5) and in the Resonant Frequency (Fres) in comparison with non-atopic healthy controls. In this study it was confirmed that the most important changes occurred 2 minutes after finishing the exercise and that an increase in R5 over 35% can be considered an abnormal response to exercise, suggesting EIB [5]. Another study conducted in preschoolers with EIB measured by IOS and defined as an increase in R5 over 40%, demonstrated that the severity of EIB is correlated with higher levels of exhaled nitric oxide (FENO) in atopic than non-atopic children. Furthermore, FENO had a higher predictive value for EIB in IOS in atopics than in non-atopic wheezers, suggesting a different interaction between bronchial response and airway inflammation in non-atopic wheezers [6]. On the other hand, it has been shown that ECT with the free running of 6-8 minutes measured with IOS (R5 ≥ 40%) in children from 3 to 8 years old is capable of distinguishing children with probable asthma well symptomatic of those with other conditions such as early recurrent wheezing, bronchopulmonary dysplasia, and healthy children [7]. A 6-month follow-up study carried out in preschoolers with asthma demonstrated that treatment with inhaled corticosteroids significantly reduces the percentage of BIE measured by IOS and defined as an increase in R5 ≥ 40% after exercise, so this parameter can also be used to monitor the effectiveness of the treatment [8]. Figure 2 shows an example of an exercise challenge test with IOS measuring R5.

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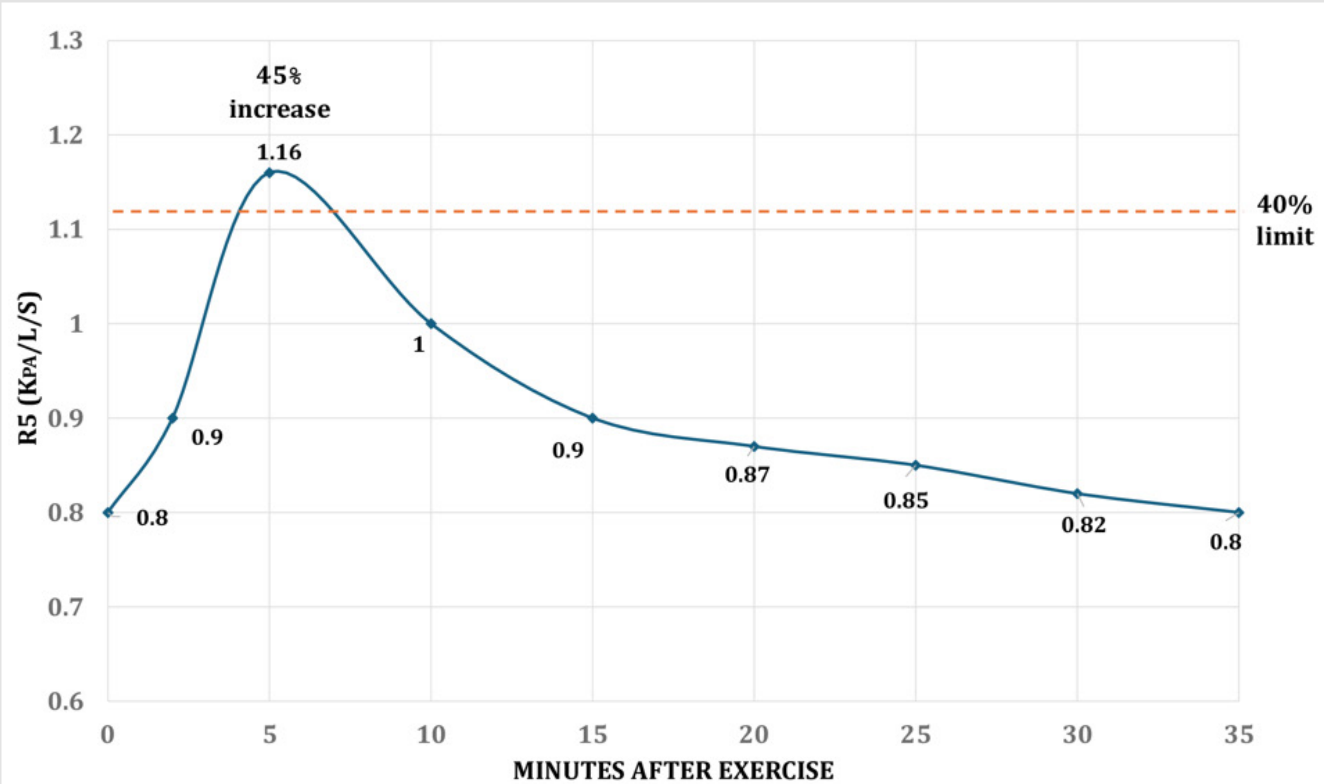

Figure 2: Positive exercise challenge test with IOS in 5-year-old preschool. 5 minutes after the exercise, R5 (resistance at 5 Hertz) rises to 45%. The value at 35 minutes is after bronchodilation.

Children and Adolescents

In a cross-sectional study conducted on 74 children and adolescents with a previous diagnosis of asthma, aged between 7 and 17 years old, it was shown that AX, R5, and Fres had a moderate negative inverse correlation with FEV1 at 5 minutes after the end of the exercise ($r = -0.69$, $r = -0.64$ and $r = -0.53$, respectively, all with $p < 0.05$). In this study, cut-off points are also proposed in AX, R5, and Fres to discriminate between patients with and without EIB (FEV1 drop ≥ 10%,) however, the positive likelihood ratios were low and of little clinical relevance (LR+ 1.67, 1.75 and 2.08, respectively) [9]. Another study carried out in asthmatic children and adolescents aged 6 to 15 years showed that the parameter that best discriminates between patients with or without EIB confirmed by a 10% drop in FEV1 is R5 in IOS. In this study, the best cut-off point was found with increases in R5 at 30 minutes ≥ 14.1% of baseline (AUC = 0.74) with a low positive predictive value (PPV = 33.9%) and a high negative predictive value (NPV=97.5%), so the greatest use in this cut-off point is to rule out EIB if the R5 value is less than 14.1% [10]. A controlled study was recently published with 68 asthmatic or clinically suspected children and adolescents aged 6 to 16 years who reported symptoms with exercise. In this study, mean within breath differences in Resistance (Rrsexp-Rrsinsp) and Reactance (Xrsexp-Xrsinsp) were calculated, finding that the mean difference Xrsexp-Xrsinsp was higher in those with EIB than those without it, especially 18 minutes after exercise [11]. Figure 3 shows an example of a child who, after exercise, increases the reactance difference within the respiratory cycle.

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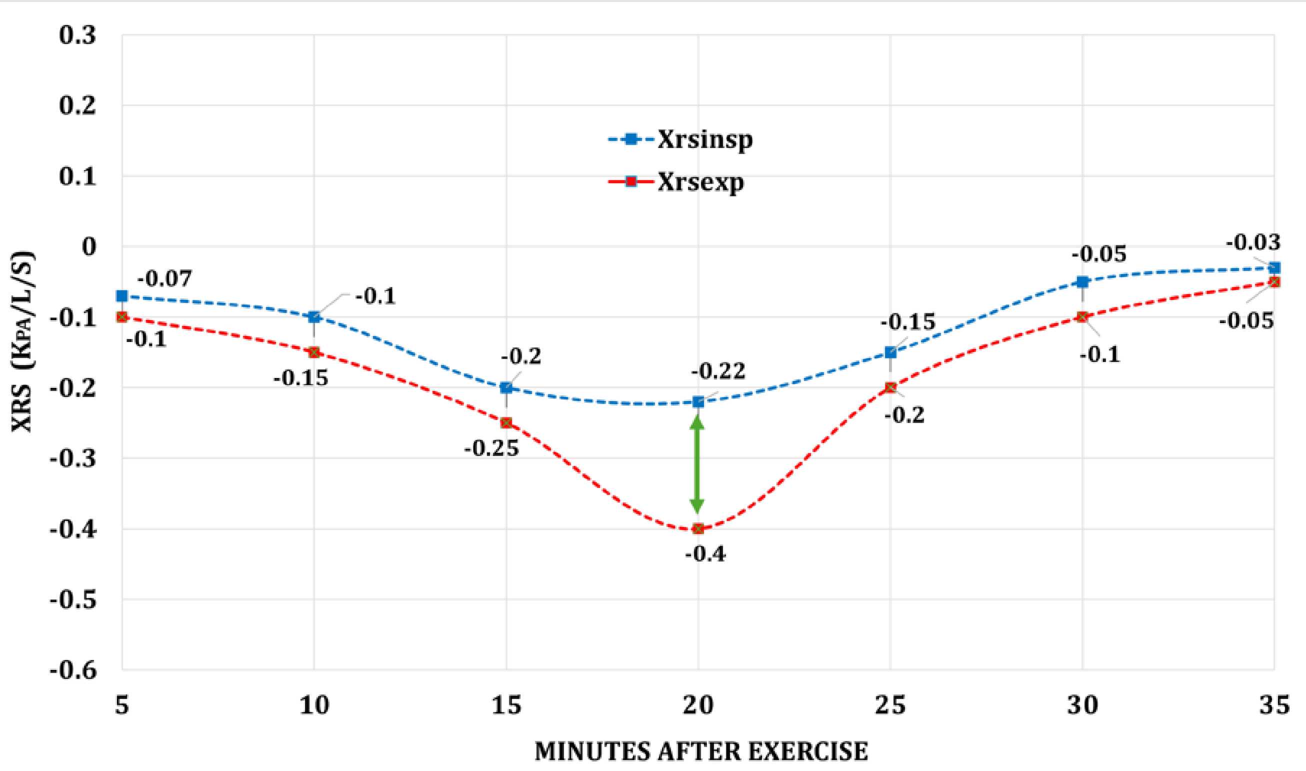

Figure 3: Breath differences in reactance (Xrsexp-Xrsinsp) after exercise in an 8-year-old asthmatic patient. The bidirectional green arrow indicates that the greatest difference occurs 20 minutes after exercise. The value at 35 minutes is after bronchodilation.

Conclusion

Monitoring IOS parameters after exercise may be an alternative method to detect EIB when the patient cannot perform the conventional test with FEV1 measurement. In preschool IOS, increases in R5 above 35-40% have been shown to be effective for the diagnosis and monitoring of EIB. In children and adolescents, the cut-off point for R5 is lower and would be more useful in ruling out EIB than in confirming it. Differences in reactance within breathing are a promising alternative to diagnosing EIB in children and adolescents, which must be corroborated with more studies.

Conflict of Interest Statement

The author has no conflicts of interest to declare.

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