



Exercise test indications in children and adolescents*

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ABSTRACT

The exercise test (ET) is a low-risk procedure that presents extremely rare complications, especially among pediatric age populations. In this reviewing, the main ET indications in children and adolescents (age up to 19 years) are presented as a method of diagnostic, prognostic and functional evaluation in several situations: evaluation of the physical capacity, evaluation of symptoms related to exercise, evaluation of clinical and surgical treatments in patients with cardiomyopathies, congenital and valvar cardiopathies, asthmatic patients and pre-participation in physical activities programs, among others.

Adult patients have as most frequent indication of ET the search for diagnostic information, when intermediate probability of significant coronary arterial disease occurs in the absence of significant alterations of the ECG in rest⁽¹⁾. The ischemic disease is rare among young populations, what shows a significant difference in indication and interpretation and results in low risk in the ET routine in the pediatric age population. The complications are extremely rare even when ET is performed in children with congenital cardiopathies and arrhythmias. The ET applications in young individuals are mainly related to the measure of the physical capacity, evaluation of known cardiac abnormalities and evaluation of symptoms related to exercise⁽²⁾.

The ET indications of the American College of Cardiology (ACC) and American Heart Association (AHA)⁽²⁾ in children and adolescents, according to classification I to III of the recommendation degrees (table 1) are:

TABLE 1

ACC/AHA⁽⁸⁾ classification used for the procedure recommendation degrees

Class I:	Condition in which there are evidences and/or general agreement that the procedure performance is acceptable and effective.
Class II:	Condition in which there are evident conflict and/or opinion disagreements on the procedure's acceptance or effectiveness.
Class II a:	Higher weight of the evidences and opinions in behalf of the effectiveness acceptance.
Class II b:	Acceptance and effectiveness less established with regard to the evidences and opinions in behalf of.
Class III:	Conditions in which there are evidences and/or general acceptance that the procedure is not accepted neither effective and in some cases it may even be harmful.

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Class I

1. Evaluation of the exercise capacity in children with congenital cardiopathies, children submitted to congenital cardiopathies surgical treatment, with valvar acquired disease or myocardial disease.
2. Evaluation of children with complaints of thoracic pain due to angina.
3. Follow-up of the heart pacing response to exercise.
4. Evaluation of symptoms related to exercise in young athletes.

Class II a

1. Evaluation of the response to medical and surgical treatment or ablation by radio frequency in children with tachyarrhythmia observed in previous ET.
2. In the follow-up of the acquired or congenital valvar lesions repercussion, especially aortic valvar stenosis.
3. Evaluation of the rhythm during exercise in patients with suspicion of exercise-induced arrhythmia or when this arrhythmia was diagnosed from exercise.

Class II b

1. As one of the evaluation components of children and adolescents with family history of sudden death of young individuals during exercise.
2. Follow-up of cardiac abnormalities with late coronary involvement possibilities such as Kawasaki disease and systemic eritematous lupus.
3. Follow-up of the cardiac frequency response and the development of ventricular arrhythmia in children and adolescents with congenital atrium-ventricular total obstruction.
4. Quantification of the cardiac frequency response during exercise in children and adolescents treated with beta-blocker agents to assess the adaptation to the beta-adrenergic obstruction.
5. Measure of the shortening or prolongation response of the QT interval corrected in exercise as an aid in the diagnosis of the QT interval prolongation congenital syndrome.
6. Evaluation of the blood pressure and/or arm/leg gradient response after surgically corrected aortic coarctation.
7. Follow-up of the desaturation degree with exercise of patients relatively well compensated or submitted to palliative surgery of cyanotic congenital cardiopathies.

Class III

1. Evaluation before the participation in sportive activities in healthy children and adolescents.
2. Routine in the investigation of typically non-anginous thoracic pain, common in children and adolescents.
3. Evaluation of atrial and ventricular extrasystoles in children and adolescents apparently healthy.

ET is also indicated to evaluate the stress tolerance and to identify the mechanisms that limit the physical capacity in children with cardiac diseases or other diseases: a) to evaluate symptoms or

signals that may be induced or worsened by exercise; b) to identify abnormal adaptation to exercise in patients with cardiopathies or other diseases; c) to evaluate the effectiveness of the surgical or clinical treatment; d) to assess the functional capacity and the security for the participation in athletic or recreational physical activities; e) prognostic evaluation; f) to establish limits and the follow-up of the cardiac rehabilitation effectiveness⁽³⁾.

Bozza & Loos⁽⁴⁾, who present one of the largest experiences on ET in children and adolescents in our country, describe the main indications among this population: a) to evaluate stress-induced or worsened specific signals and symptoms; b) to detect abnormal adaptive responses in cardiopath and non-cardiopath patients; c) to detect possible abnormalities in the relation between the offer and intake of myocardic oxygen in patients with thoracic pain or syncope; d) to detect dysfunctions of the cardiac rhythm associated to exercise or not; e) to observe the blood pressure response to stress; f) to evaluate the medical or surgical treatment; g) to evaluate prognostics; h) to evaluate functional capacity levels for the participation in vocational, recreative and sportive activities.

In the author's initial results, in 1992, among 337 children and adolescents submitted to ET, the main indications were: evaluation of the thoracic pain (35.6%), pre-participation evaluation – normal and athletes (24.9%), mitral valve prolapse (15.4%), arrhythmias evaluation (12.2%), evaluation of the blood pressure (4.5%), evaluation of non-operated congenital cardiopathies (2.4%), post-surgical evaluation of congenital cardiopathies (1.5%), remedies use evaluation (1.5%) and other indications (2.1%)⁽⁵⁾.

The ET performance in the pre-participation evaluation of sportive activities in healthy children and adolescents is considered as useless by the ACC/AHA⁽²⁾. However, according to Vivacqua Costa⁽⁶⁾, the execution of the ergometric test is indispensable for the cardiorespiratory evaluation of adolescents who will initiate the sportive practice. The sport cardiology section of the Dante Pazzanese Cardiology Institute (IDPC) in São Paulo, evaluated 700 children and adolescents with ages ranging from 8 and 16 years, athletes or beginners, and found abnormalities in 147 (21%). These findings corroborate the opinion that all children who begin a sportive modality must be submitted to a careful medical evaluation in order to detect possible cardiopathies. In the IDPC, as routine of pre-participation tests for the practice of sports, the exercise test is included with other exams in the routine investigation protocol⁽⁷⁾.

The ET routine performance in the investigation of non-anginous thoracic pain, common among children and adolescents is also referred as clinically useless by the ACC/AHA⁽²⁾, however, the ET is frequently indicated in this age range. Stress-induced asthma should be considered in pediatric patients with thoracic pain symptoms or dyspnea associated to exercise. In the evaluation of 180 young individuals with thoracic pain or dyspnea associated to exercise, 9.5% of patients with pain and 21.2% of patients with dyspnea developed stress-induced asthma⁽⁸⁾.

Although rare in children, the ischemic response should be investigated in the evolution of the coronary involvement in the Kawasaki disease. The ET associated to echocardiogram⁽⁹⁾ or to myocardial cintilography⁽¹⁰⁾ may identify ischemic alterations in patients with higher risk of myocardium infarct or sudden death.

Myocardial ischemia and effort tolerance should be evaluated after surgical treatment for the correction of the great arteries transposition with the re-implantation of the coronary arteries. Weindling *et al.*⁽¹¹⁾, in 1994, evaluated 43 children with echocardiogram, Holter monitor, exercise test and myocardium cintilography and concluded that normal exercise tolerance, absence of symptoms or electrocardiographic alterations are indicative of normal myocardial perfusion. Massin *et al.*⁽¹²⁾ performed ET in 50 children with ages ranging from four and nine years and found three tests with alterations suggestive of ischemia during effort: after hemodynamic study, the authors identified occlusion of the left coronary of an

young individual and occlusion of the right coronary in two other young individuals who presented ventricular extrasystole in rest and developed ventricular tachycardia during exercise. The other children presented normal effort tolerance and absence of symptoms suggestive of myocardial ischemia.

Arterial hypertension represents another important indication. The blood pressure response should be evaluated after surgically corrected aortic coarctation, where even after surgeries successfully performed, the life expectancy is reduced, 1/3 of the patients remained hypertensive and the hypertensive response is more frequent if compared to the normal population during exercise⁽¹³⁾. Lower effort tolerance and blood pressure abnormal accentuation were observed among adolescents and young adults after renal transplant, suggesting that precautions should be taken in the performance of intense physical activities⁽¹⁴⁾. Children with high levels of LDL-cholesterol presented higher systolic and diastolic blood pressure levels before, during and after exercise. The blood pressure response altered in the presence of hypercholesterolemia is a result of the endothelium alterations and increments of the vascular resistance⁽¹⁵⁾.

To increase the physical activity may be the main non-pharmacological therapeutic measure to reduce the blood pressure besides seeming an excellent preventive strategy for young patients with high risk of hypertension and obesity. Gillum described the ET in over than 6,700 young individuals between 12 and 17 years old in the evaluation of the relation between tolerance and effort, blood pressure, weight, body fat, cholesterol serum levels, uric acid and other cardiovascular risk factors⁽¹⁶⁾. Matthys & Verhaaren observed hypertensive response to effort in ET performed in 48 children submitted to CIA surgery and in 53 children submitted to CIV surgery⁽¹⁷⁾.

The evaluation of the hemodynamic and cardiorespiratory response may be performed with ET before and after surgical treatment of several congenital cardiopathies (inter-atrial and inter-ventricular communication, aortic and pulmonary stenosis, persistence of the arterial canal, bolster defects and tricuspid insufficiency). After surgical correction, an increase on the oxygen intake and the systolic blood pressure in the effort peak may be observed⁽¹⁸⁾. The ET was also used by Cumming⁽¹⁹⁾ to evaluate the effort tolerance of 830 children with cardiopathies (inter-atrial and inter-ventricular communication, persistence of the arterial canal, aortic coarctation, pulmonary stenosis, Fallot's tetralogy and rheumatic cardiopathy) and to compare findings with 715 children apparently healthy.

The full evaluation of the Fallot's tetralogy after surgical correction with ET and other complementary tests is important to allow the release for the practice of physical and sportive activities⁽²⁰⁾. The presence of symptoms, the cardiac frequency response, ischemic alterations and the oxygen intake should be observed during the practice of exercise⁽²⁰⁻²²⁾.

The ET may be used as coadjuvant in the evaluation of the valvar diseases repercussion. Asymptomatic children with aortic insufficiency and light functional involvement present no significant difference on the effort tolerance, $\dot{V}O_2$, CF, BP and ST segment if compared to healthy children. Depressed response of the cardiac frequency, systolic hypertension and subendocardial ischemia may be observed in the group with higher repercussion⁽²³⁾. The effort tolerance, the elevation on the cardiac frequency and the $\dot{V}O_2$ max are good indicative of the follow-up after aortic valve exchange⁽²⁴⁾.

In the mitral valve prolapse (MVP), the symptoms (thoracic pain, dyspnea and palpitations) and the alterations on the ECG in rest may be well evaluated during effort. Rokicki *et al.*⁽²⁵⁾ observed normal tolerance to exercise and normalization of the ECG during effort in patients with electrocardiographic alterations in rest and that the exercise either caused no worsening or improved the arrhythmias present in rest.

With ET, the severity of the dilated and hyperthrophic cardiopathies, obstructive or not, may be evaluated by observing the

effort tolerance, blood pressure behavior, electrocardiographic alterations and arrhythmias⁽²⁶⁾. The cardiopulmonary effort test with measurement of the exhaled gases and the direct determination of the anaerobic threshold and $\dot{V}O_2$ max is one of the most important tests to evaluate the severity of the cardiac insufficiency and the effectiveness of the treatments performed⁽²⁷⁾.

The prevalence of arrhythmias in children and adolescents apparently healthy was described by Greco *et al.*⁽²⁸⁾, who studied 500 young individuals between 4 and 17 years old, in 1983, recruited from local schools. Respiratory sinus arrhythmia was found in 97% of children in supine position. In this analysis, an individual presented supra-ventricular and ventricular extrasystoles, while other three individuals presented slow ventricular tachycardia, Wolff-Parkinson-White (WPW) and short PR interval (PRI), respectively. No symptoms related to the findings were observed. The exercise suppressed the ventricular tachycardia, the extrasystoles were reduced and no other arrhythmia was provoked.

In the evaluation of the cardiac arrhythmia performed in 2,761 patients with suspicion or diagnosed cardiopathy, Bricker *et al.*⁽²⁹⁾ observed ventricular tachycardia in 22 of them (14 during effort and 8 after exercise), most of them with cardiac abnormalities: long QT syndrome (2), arrhythmogenic dysplasia of the right ventricle (4), MVP (2), myocardiopathies (3) and congenital cardiopathies (6). No complications were observed. In another study, the ET was useful in the evaluation of children and parents with arrhythmogenic dysplasia of the right ventricle, where the familiar involvement is frequent. The presence of earlier ventricular tachycardia and the development of later cardiac insufficiency may be observed in this syndrome⁽³⁰⁾.

In the Wolff-Parkinson-White's syndrome, the ET performed in children and adolescents between 4 and 16 years old was able to identify the appearance of arrhythmias (supra-ventricular and ventricular extrasystole or supra-ventricular tachycardia) and the disappearance and/or appearance of the delta wave during or after exercise. Children with WPW with total QRS normalization during exercise and with no tachycardia symptoms require no electrophysiological study⁽³¹⁾.

Matina *et al.*⁽³²⁾ studied children and adolescents between 8 and 18 years old with congenital atrial-ventricular obstruction (AVO) and ventricular pre-excitation. In the AVO, the worsening of the ob-

struction degree during effort may justify an electrophysiological study. In the pre-excitation, the ET may aid in the evaluation of the normal and accessories ducts refractory period and, according to these authors, the tachycardia appearance justifies the electrophysiological study. On the other hand, the ECG normalization in asymptomatic individuals enables the release for the practice of physical activity. The ET in children submitted to heart pacing implant may evaluate the tolerance to exercise, symptoms, cardiac frequency response and arrhythmias during effort⁽³³⁾.

The ET may be used in the identification of children with asthma episodes provoked by the exercise and in the follow-up of the physical training effect on the decrease of the asthma episodes with the effort⁽³⁴⁻³⁶⁾. The appearance of symptoms and alterations on the respiratory gases during and especially after exercise may identify the bronchospasm with effort present in 75 to 95% of asthmatic individuals and in 3 to 11% of non-asthmatic individuals⁽³⁷⁾. In children with cystic fibrosis, the ET was used to assess the tolerance to effort and the response to the treatment with aerobic and resisted physical training program^(38,39). In the ET performance in 59 patients with average age of 11.4 years after extensive burns and inhalation lesions, no differences on the functional capacity were observed⁽⁴⁰⁾.

The ET performance in obese children and adolescents showed lower functional capacity in the presence of hyperinsulinemia⁽⁴¹⁾ and in the metabolic syndrome⁽⁴²⁾. Children between 3 and 18 years old, carriers of localized sclerodermy, showed disturbances on the conduction through the right branch on the ECG in rest, valvar alterations predominantly mitral in the echocardiogram and absence of alterations on the ET⁽⁴³⁾. No significant differences were observed in the exercise tolerance, blood pressure behavior or electrocardiographic alterations in children from the age of seven submitted to ET after acute lymphoblastic leukemia treatment⁽⁴⁴⁾.

One concludes that the exercise test is a safe procedure that may be used as important method of diagnosis, prognosis and functional evaluation in several clinical or surgical situations in the population not older than 20 years.

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