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REVIEW PAPER

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Applicability of Cardiopulmonary Exercise Test

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ABSTRACT

Introduction. Cardiopulmonary Exercise Testing (CPET) test is a test that allows an integrated response to the physical effort of the cardiovascular system, respiratory system, nervous system, skeletal muscles and metabolism. The growing awareness of better correlation between health condition and exercise tolerance than with resting measurements is the key importance. The range of clinical applications is expanding to assess impairment of physical capacity with an unclear cause and to objectively determine functional capacity.

Aim. The aim of this review was to discuss the applicability of cardiopulmonary exercise test in diverse branches of clinical and non-clinical use.

Material and methods. This review was performed according to latest literature. We mainly searched PubMed and Google Scholar to look for previous cases of CPET applicability.

Results. CPET has a very wide range of applications for the diagnosis of physical productivity as seen through athletes and amateurs in their own right. This medical diagnostic practice allows us to map out the inconsistencies the blood, respiratory and bone systems/structures.

Conclusion. Cardiopulmonary exercise test is a safe method of different disease assessment. It can be use in various cases, to rate reaction of an organism to physical effort.

Keywords. cardiopulmonary exercise test, CPET, stress test

Introduction

Physical activity is something that involves all of your muscles, which leads to an increased energy expenditure, higher than that of an individual resting state. It is an integral part of an organisms functionality, while also having a positive impact on an individual health and lifestyle.[1] Physical activity is crucial in overall development, height, as well as the physiological functioning

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of cells. Physical activity counteracts obesity, fat gain, while halting almost entirely the development of diabetes. Regular physical activity has a positive effect on an individual blood network, bone structure, and overall respiratory function.[2] By examining a training structure, we can point out the effect that physical activity has on the body, and in the case that something bad happens (i.e some form of injury), we can deduce which system in our body is most likely responsible.[3]

Physical tests can be split into two groups: simple and complex. To the first group we add the stair test, where an individual climbs a set of stairs, as well as a simple walking exercise, of which the most meaningful is a 6 minutes walk test – 6MWT. However, the main representative of complex test is the cardiopulmonary exercise test CPET.[3] The methods of measuring physical activity can also be split into two groups—subjective and objective. To the first one we add a diagnostic survey, in which the studied individual relays to use their typical day to day routine of physical activity. To the objective methods we distinguish instead; indirect, which focuses on kinematic analysis as well as measuring blood pressure during physical activity, on the other hand the direct, which takes advantage of the metabolic criteria, for example human heat expenditure, carbon dioxide, and oxygen levels.[4]

In clinical applications the most meaningful is cardiopulmonary exercise test CPET, which belongs to the direct and objective group of examination for the measurement of physical activity. The test is a combination of attempts at exercise along with measured gases found within your respiratory system, allowing us to check the functionality and overall status of the cardiovascular, respiratory, neurophsycological, hemopoietic, and muscular systems in their reaction to controlled physical activity. The tests are performed either on a treadmill or stationary bicycle, and the results are mapped out in the following order: maximal oxygen uptake ($VO2_{peak}$), carbon dioxide emission (VCO2), minute ventilation (VE), ventilatory threshold (VT), ventilatory equivalents for oxygen (VE/VO2) and carbon dioxide (VE/VCO2), respiratory exchange ratio (RER, VCO2/VO2), forced expiratory volume in 1 second (FEV1), peak expiratory flow (PEF), saturation (SatO2), ECG, blood pressure (BP), heart rate (HR).[5, 6]

CPET has a very wide range of applications for the diagnosis of physical productivity as seen through athletes and amateurs in their own right. This medical diagnostic practice allows us to map out the inconsistencies the blood, respiratory and bone systems/structures.[6, 7]

Aim

The main goal of the work, was to find and describe the wide use of the CPET test in various fields of clinical and non-clinical research. The focus was on the description of the practical application of the test, proceedings, test variables and its use in clinical and non-clinical studies.

Material and methods

Google Scholar, PubMed, Science Direct and available literature from the publications were searched to find information about the test. Selected words like CPET, CPX, Cardiopulmonary Fitness were used to search for test data.

CPET-Praxis

Cardiopulmonary Exercise Testing CPET has many significant clinical and research appliance.[8-10] Cardiopulmonary exercise test offers the researcher the opportunities to study in same time, the cardiovascular, the ventilator and the cellular systems responses under circumstances of accurately controlled metabolic stress.[11] Spiroergometry is used for the evaluation of endurance in the physical effort, which intensity is determined on the basis of the physical effort on treadmill or cycle-ergometer.[12] On cycle-ergometer the patient rotates the pedals at 60 turnovers per minute. The pedalling rhythm may be controlled by using the speedometer or metronome.[13] The most common protocol used in treadmill and cycle-ergometer is the Bruce protocol. The protocols with smaller, gentler load increments (Cornell, Naughton) or ramp type of protocols, in which the load grows constantly, continuously are also recommended.[14] Myers and Bellin, claim that individualizing protocol of exercise, including personalized growth of work, demands some wide knowledge of the patient's exercise capacity prior to the test, and it has been one of the obstacles in the test.[15] The test consists in an electrocardiographic exercise test with the measurement of the blood pressure, monitoring of cardiac function to show the occurrence of conduction disorders and rhythm. The subject is wearing a mask that measures the exhaled air in terms of determining the vital capacity of the lungs and detecting possible lung obstruction. The oxygen and the carbon dioxide concentrations in the exhaled air are also measured. Owing to the fact, we can analyse the metabolism that occurs during exercise in the body.[14,16]

Applicability

Previously, the physical capacity was described as a value based on the maximum amount of work obtained on the treadmill or cycle-ergometer. The CPET test was limited to pulmonary medicine and physiologists. Today its usage is wider. Researchers increasingly appreciate the precision and additional information obtained from the test. They provide parameters related to assess the inheritance and degree of cardiovascular disease and stratifying risk.[17] CPET test in cardiology is used in patients with cardio-vascular diseases such as heart failure or congenital heart disease. It could be also used in assessment of heart performance and to prognosticate the health condition of patients with chronic health failure.[18] Stress test helps to qualify patients for heart transplantation and to assess the effectiveness of cardiologic rehabilitation.[19] The cardio-

vascular shortage has a close impact on different systems and organs, such as the renal, the skeletal and the pulmonary. CPET is helpful in adult congenital heart disease patients who have had a limited exercise performance and adjust to increasing symptoms of heart failure by reducing their functional level.[20,21] Cardiopulmonary exercise test is regarded as "gold standard" for the functional assessment of patients with congestive heart failure CHF, using prognostic and diagnostic data coming from direct measurement of different parameters such as VO2, VCO and VE.[22] Examples of using the CPET test conducted on people with CHF was mainly used to obtain forecast data.[23] The CPET test was also used to optimize exercise tolerance in patients with chronic heart failure by examining the effect of placebo on physical performance.[24] Cardiopulmonary exercise test can also be used to calculate the maximum heart rate. This is one of the method that characterizes the maximum effort of a person. An example is a study which has been done to optimize the heart rate in beta-blocked heart failure patients. Information derived from CPET test may be useful in rehabilitation programs and ischemic test, or to find criteria which determines maximal oxygen uptake.[25] Ramp-incrementation rate remarkably effects the RER during exercise testing in patients with congestive heart failure.[26] Confirmation of the usability of the test can also be found in the comparison of test results obtained from the 6-minute test or step test. The range of the results received evaluates efficiency and its prognosis is significantly wider.[27] The use of this research tool made it possible to compare the likelihood of death in patients with CHF. Studies have shown that comparing each of the parameters with the exception of RER, was meaningly different.[28] Using VO2 peak as an final point, coherent changes in mortality and VO2 peak were seeming for interventions such as cardiac resynchronization therapy (þ/þ for change in VO2 and improvement in mortality, respectively.[29,30] On the other hand Barocco et al. assesses the leg muscle oxygenation during effort in patients with heart failure.[31]

In another study the CPET test is used to assess the toleration of the physical effort and in diagnostic of dyspnoea during effort.[32] In pulmonology also CPET is used in assessment of patients with pulmonary diseases, to evaluate transplanted lung or heart-lung and to assess the effectiveness of respiratory rehabilitation.[33] The study showed that the CPET test is relatively safe in patients with inoperable lung cancer and may be the basis for planning further stages of rehabilitation for these patients.[34] Like in cardiovascular disease in the lung cancer treatment, we are able to investigate the curative intent and prognosis.[35,36] CPET in studies of respiratory diseases is also used in a wide spectrum. The trial was carried out on pulmonary hypertension. The test helped in determining the degree of functional impairment, the severity of the disease, assessment of interventional efficacy and prognosis of the disease.[37] In the study of patients with chronic obstructive pulmonary disease and idiopathic pulmonary fibrosis , the test was also used.[38] Holverda et al. characterized whether the existence of pulmonary hypertension is associated with cardiovascular parameters and gas exchange results during cardiopulmonary exercise testing.[39]

Cardiopulmonary exercise test helps in adjusting physical activity also in other civilization diseases such as obesity or diabetes. CPET is directed ahead of exercise intervention in adolescents with obesity to estimate medical safety of exercise and physical performance, or to assess exertional dyspnoea in obesity.[40-42] It was observed that in a child with obesity it is hard to individualize the variables obtained from the CPET test, because the fat contained in the organism "virtually metabolically inactive during exercise" can hide the result of the metabolically active muscle tissue when cardiopulmonary exercise test is standardize to body mass.[43] Most often referring to Faria et al, exercise test is carried out to assess the influence of obesity to pulmonary function or heart failure.[44,45] The test can be carried out among adults, children and adolescents. Examples of this are the study of children with type 1 diabetes (T1DM) .The safety and need to conduct research on a wider scale is confirmed by latest International Society for Pediatric and Adolescent Diabetes ISPAD guidelines. It is necessary tool to cope with diabetes and to widen the management with this disease.[46] Adolfson et al. performed research on group of adolescents with diabetes mellitus type 1. Group of investigators found no differences which were significant. It shows that for this group of patients CPET is safe and they can participate in physical activity.[47,48] CPET on patients with diabetes type 2 can also be executed.[49] The influence of smoking can be also taken into consideration.[50]

In the study of Przednowek et al., the predictive statistical model of VO2max was made. It opens a wide range of mathematic and statistic cooperation. This research was made on 80 male physical education students.[51] It presents that also conducting study on healthy people is very important. We are able to diagnose a broad scope of healthy participants and find risk factors of presumable complications during physical activity.[52,53] Referring to Salvati et al., the cardiopulmonary exercise test is a crucial method to rate fitness, endurance and performance in sportsmen.[54]

Conclusion

Cardiopulmonary exercise test under controlled conditions can safely assess the body's response during dynamic exercise of increasing intensity. CPET is used not only in scientific research. The performance of this functional non-invasive test is increasing systematically in everyday clinical practice.

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