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Maximal heart rate percentage in relation to maximal oxygen consumption percentage in spastic patients

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ABSTRACT

The use of heart rate as an index of training intensities has been widely accepted for healthy people. Recently, a number of studies have demonstrated that relationship between %HRmax and %VO2max described by American college sport science (ACSM) is not applicable to the some disorders. The objective of this investigation was to determine the relationship between %HRmax and %VO2max in 25 adolescent with diplegia spastic cerebral palsy. HR and VO2 responses to at rest and each stage of a standard ergometery protocol were measured in 25 adolescent with spastic that participated in study with consent of their parents as well as specialist physician. These parameters were then used for calculation %HRmax and %VO2max in all stages. A spearman method was conducted to determine correlation between %HRmax and %VO2max. Although, the study findings showed a significant correlation between %HRmax and %VO2max, but their regression line is not according to the identity line. These results suggest that the relationship between these indexes is not similar to guideline of ACSM in spastic patients. Thus, the %HRmax versus %VO2max relationship should be determined directly in each patient.

Keywords: spastic, exercise intensity, ergometer, heart rate.

INTRODUCTION

Intensity is an essential part of the traditional cardiovascular exercise-rehabilitation recommendations. An optimal exercise prescription for improving in cardiovascular fitness is a balance between the frequency, intensity and duration of exercise and exercise-rehabilitation mode [1]. Exercise intensity is a major factor affecting the efficacy of an exercise intervention [1]. Using the appropriate exercise intensity when prescribing exercise-rehabilitation is an important factor in effectively improving cardiorespiratory fitness. American college of sport medicine (ACSM) has recommended that the appropriate exercise intensity for improving cardiorespiratory fitness for apparently healthy adults as: 60-90% of age-predicted maximal heart rate (HRmax), 50-85% of maximal oxygen uptake (VO2max) for healthy people [2]. But weather this guideline is suitable for all populations such as elderly, children, young particularly patients kinds or rehabilitation program. Furthermore, some researches have investigated the accuracy of the ACSM guideline and equation for difference diseases and design training program with proper exercise intensity for rehabilitation in difference patients. Most studies concerning the optimal exercise therapy have typically used the research design in which comparisons were made across different levels of exercise intensity [3, 4]. Recently, the some research showed that relationship between %HRmax and %VO2max described by ACSM is not accuracy applicable to the some normal population and patients or nonhandicapped people [5, 6, 7]. The study by swain et al showed that the fitness level is significantly affecting the relationship between exercise intensity indexes [8]. A review on studies in this area indicates that regardless the accuracy ACSM guideline for prescription exercise intensity for healthy people but the relationship between exercise intensity indexes should be determined directly in each patient [9]. Therefore, the primary purpose of this study was to determine the %HRmax versus %VO2max relationship in adolescent with Dipelegia spastic cerebral palsy (CP) during ergometer submaximal test by means of prescription the exercise-rehabilitation program with suitable exercise intensity for these patients and to examine the accuracy of the ACSM guideline for this population.

MATERIALS AND METHODS

Subjects: Twenty-five boy adolescent (age; 12±2 years, height; 131±6.3 cm, weight; 29.8±5.6 kg) with spastic cerebral palsy were recruited with the consent of their parents as well as specialist physician. The intensity of spasticity in patient children was average to severe or three degree according to ashword scale [10]. The exercise protocol and all possible risks and benefits associated with participation in the study were explained to each subject and their parents. Written informed consent was obtained from the parents of all participants. This study was approved by Ethics Committee of Islamic Azad University, Iran. All participants were screened using a physical activity readiness questionnaire (PAR-Q) and a medical history questionnaire to ensure they were physically able to participate in the testing. All subjects completed an incremental exercise test to determine the individual relationship between HR and VO2.

Testing protocol: All tests were conducted at the same time of the day, between 10:00 and 12:00 h. All subjects performed the McMaster protocol (Submaximal and specific for children) [2] on an electronically braked cycle ergometer (Ergo Tunturi, E604, Finland). The patients were asked to refrain from any form of intense physical activity for the 48 h prior to testing. They were also asked to refrain from eating 2 hr prior to testing. The test was preceded by a 2 minute warm-up period. A physician supervised each test. The protocol is performed in four stages. The initial power output was set at 12.5 watt. The power output was then increased by 25 watt every 2 minute. Subjects were instructed to maintain a constant pedal rate throughout the entire test. All subjects were verbally encouraged to continue exercise until final stage. For each subject, HR and VO2 was monitored continuously, and recorded in the rest and over the last 10 of each stage of the MacMaster ergometery protocol, as well as during the final 10 s of test and used of those for calculation exercise intensity indexes (%HRmax and %VO2max). HR monitored by polar telemetry. Values for VO2 were calculated by a formula recommended by ACSM [11].

Statistical analysis: In each stage, the value of HR and VO2 was expressed as a percentage of its maximum. VO2max and HRmax were defined as the highest values attained during the incremental test. For each individual, data obtained at rest, at the last minute of each stage, and at maximum workload were used to perform linear regression between %VO2max and %HRmax and to calculate the respective slopes, intercepts, and squared correlation coefficients. After collection of the all data, a Pearson correlation were used to establish the relationship between %VO2max and %HRmax in each stage of exercise protocol of all subjects. A p-value less than 0.05 were considered statistically significant.

RESULTS

Table 1; Descriptive statistic of physical characteristics and physiological measures of participants

variable	Mean and standard deviation
Age (year)	12 ± 2
Height (cm)	131 ± 6
Weight (kg)	29.8 ± 6.5
Rest HR (bpm)	81 ± 6
Exercise HR (bpm)	163 ± 13
Max VO2 (L.min)	1.51 ± 0.21

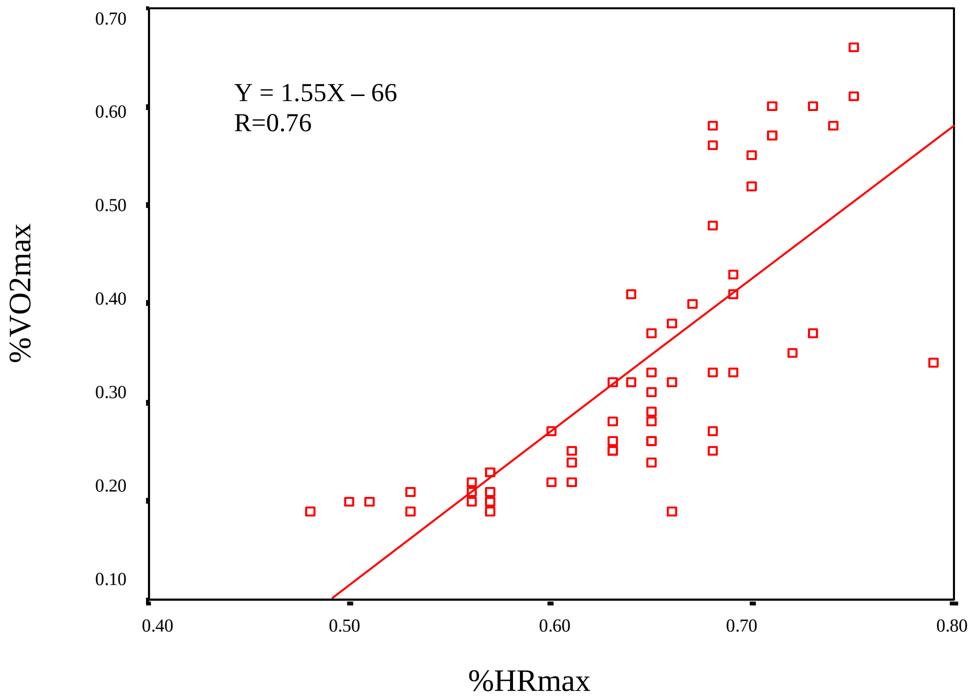

Figure 1. Regression of percentage of maximal heart rate %HRmax) versus percentage of maximal oxygen uptake (%VO2max)

In this study, we determined %VO2max versus %HRmax relationship during cycling exercise on an electronically braked cycle ergometry in adolescent with dipelegia spastic and comparison to ACSM equations. A summary of the physical characteristics and physiological data of the subjects is shown in Table 1. Data are presented as mean ± standard deviation (SD).

Both HR and VO2 values increased steadily with increased workload. Certain of participants (3 numbers) were unsuccessful finished the ergometery protocol. The equivalency between %HRmax and %VO2max for spastic patients was examined using data obtained in this study. The findings showed that regression between %HRmax versus %VO2max is line, but all regression lines were significantly different from the line of identity ($p<0.05$). The mean of the liner regressions from the subjects was %VO2max = 1.55(%HRmax) – 66. The correlation coefficient of the study sample was $R=0.76$ (figure 1). This figure demonstrated that predicted values of %HRmax were significantly higher ($p<0.05$) than the corresponding value for %VO2max for all the intensities ranging in all stages.

On the other hand, predicted values of %HRmax were significantly higher ($p<0.05$) than indicated values of %VO2max.

DISCUSSION

In our study, the equivalency between %HRmax and %VO2max was established by individual regression analysis, with the result that the %HRmax-%VO2max relationship was significantly different than the line of identity in terms of slope and intercept. Physiological benefits gained from exercise-rehabilitation training in healthy and disease people rely primarily on the exercise intensity. The prescribed intensity fraction can be alternatively applied using an absolute or relative approach. Absolute intensity is to prescribe a workload, such as 70 Watts during cycling or a set caloric expenditure in a set period [12]. In this method for intensity prescription, each person performing the set workload is under different physiological stress, relative to that person. But, the relative intensity is usually determined as a percentage of a maximum capacity, such as maximal heart rate or maximum oxygen consumption or maximum exercise capacity [12].

It is generally accepted that a critical component of cardiac rehabilitation (CR) is an individualized exercise prescription that defines appropriate type, duration, frequency, and intensity of exercise specific to the patient’s condition. Recent evidence also supports of this hypothesize that exercise intensity is the most important component, particularly in terms of safety and efficacy. In fact, exercise intensity should be set at a level induces a training effect, but does not provoke abnormal clinical signs and symptoms [13]. The use of heart rate as an index of training intensities has been widely accepted for the general population and for exercise-rehabilitation program in different diseases [14, 15]. Since heart rate is easy to measure and is linearly related to VO2, it is often used to monitor aerobic training intensity [2, 16]. In this area, Strath et al suggested that after adjusting for age and fitness level, HR was an accurate predictor of VO2 [17]. Based on the linear relationship between heart rate and oxygen uptake, a percentage of maximal heart rate (%HRmax) to elicit a predetermined percentage of maximal oxygen consumption (%VO2max) has often been used for assessing exercise intensity [18].

% HRmax compute the training HR as a percentage of HRmax. Although this method requires only the measurement of HRmax, it is limited by the individual variability in the relationship between relative HRmax and relative VO2max [16]. It is possible, this variability to be due partially to differences among individuals in resting heart rate [16]. Different approaches in the utilization of HR for prescribing exercise intensity have been proposed. It is possible to estimate exercise intensity as a percentage of VO2max from your training heart rate. Some study that performed on different populations, have found that the values obtained for estimated values of %HRmax to predict %VO2max were not accurate [6].

According to the American College of Sports Medicine (ACSM) guideline, 50, 60, 80, and 85% of VO2max represent 62, 70, 85, and 90% of HRmax, respectively [5]. However, the ACSM made these official recommendations with regard to %HRmax versus %VO2max relationship in 1991. Since then, a study by swain has criticized the mathematical methods used to derive the regression equations in previous research [6]. They are examined the relationship between these indexes and found that the ACSM formula underestimates HR at the target values of %VO2max. A review on the some studies in this area indicated that the many factors such as age, fitness level, temperature, gender, cardiorespiratory fitness, mature, disease, drug, kind and extent of disease affect equivalency between these exercise intensity indexes [5, 12, 19, 20]. Table 2 is showed some of regression equations (%HRmax versus %VO2max) together with subjects.

Table 2. The regression equations in the some difference population

Refe	Researcher	Regression equation	Subjects
[21]	Hui SS	%HRmax= 0.55 %VO2max+46.1	adolescent girls
[21]	Hui SS	%HRmax= 0.58 × (%VO2max) + 42.6	adolescent boys
[6]	Swain DP	%HRmax= 0.64 × (%VO2max) + 37	young man
[6]	Swain DP	%HRmax = 0.63 × (%VO2max) + 39	young women
[22]	Tolfrey K	%HRpeak = 0.681 × (%VO2peak) + 33.2	wheelchair propulsion
[5]	Simmons DN	%HRpeak = 0.55 × (%VO2peak) + 43.2	chronic obstructive pulmonary disease
[23]	Collins MA	%VO2max = 0.58 × (%HRmax) - 1.79	young males
[24]	Hellerstein	%VO2max= 1.41× (%HRmax) – 42	cardiac patients
[25]	Franklin	%VO2max = 1.33 × (%HRmax) – 37	women and men

There is limited research as to the exercise response of individuals with CP. This may be related to the fact that participation in exercise program has been limited in this population. In some individuals with CP, impaired motor function may cause a decrease in daily activity and diminished function with associated with physical activity [26]. As is commonly, physical and physiological fitness of people with cerebral palsy is often lower than in the healthy population. When developing exercise-rehabilitation guidelines for persons with cerebral palsy, it is important to consider secondary health conditions that may affect or limit a person's ability to participate in certain physical activities. For the person with CP, aerobic capacity and cardiorespiratory can be enhanced through exercise- rehabilitation done 40-50 percent of VO2max or HR reserve for 20-40 minutes per session, three to five days a week [2]. But, these exercise should be immune and without any risk.

The findings of our study showed that the regression equation between %HRmax and %VO2max described by ACSM is not applicable to adolescent with spastic cerebral palsy. Furthermore, the relationships between these indexes have to describe by a distinct equation. The regression equation of our study is also indicated that the kind of disease depend on influence on cardiorespiratory fitness and neuromuscular system seriously affect %HRmax versus %VO2max relationship and exercise intensity in the rehabilitation program for improving to cardiorespiratory fitness have to determine directly for the people with each disease. One probably reason for this discrepancy is influence of neuromuscular disturbance on cardiorespiratory or cardiopulmonary system. Based on our data and previous studies, it was concluded that the relationship between exercise intensity indexes should be determined directly in each patient.

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