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Investigation relationship between %VO2$_{MAX}$ versus %HR$_{MAX}$ in children with cerebral palsy

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Abstract

Certain studies demonstrated that some factors particularly kinds of disease are influenced the relationship between exercise intensity indexes. %HRmax and %VO2max are two indexes of exercise intensity on exercise- rehabilitation in some diseases. Recently, the some research showed that relationship between %HRmax and %VO2max described by ACSM is not applicable to the some patients or no handicapped people. **Objective:** This study performed with aim to determine relationship between %HRmax and %VO2max in leg exercise in 20 adolescent with dipelegic spastic cerebral palsy(12±2 year of age). **METHOD:** Twenty children with dipelegic spastic cerebral palsy participated in this study by voluntarily and the consent of their parents as well as specialist physician. HR and VO2 responses to McMaster ergometery protocol monitored continuously at rest, end of each stage and the end of protocol. These parameters were then used for calculation %HRmax and %VO2max in subjects. The correlation between these indexes determined via statically SPSS. Regression analyses were conducted to determine correlation between these indexes. **RESULTS:** The statically data indicated that percentage of heart rate max is not equivalent with percentage of VO2max. In the other words, at each stage of protocol the values of %HRmax was very upper than %VO2max in comparison with those used by the ACSM. **CONCLUSION:** Our findings demonstrated that the relationship between %HRmax and %VO2max in these patients is not equal to guideline of ACSM. In addition; in each disease depend on influence in physical and cardio respiratory fitness affect the relationship between exercise intensity indexes. Therefore, the %HRmax versus %VO2max relationship should be determined directly in each patient.

Keyword: Spastic; exercise intensity; ergometer; heart rate.

1. Introduction

Intensity is an essential part of the traditional cardiovascular exercise recommendations. An optimal exercise prescription for competitive training as well as for fitness improvement is a balance between the frequency, intensity and duration of exercise and exercise mode (1). Exercise intensity is a major factor affecting the efficacy of an exercise intervention (1). Using the appropriate exercise intensity when prescribing exercise is an important factor in effectively improving cardiorespiratory fitness. American college of sport medicine (2) has recommended that the appropriate exercise intensity for improving cardiorespiratory fitness for apparently healthy adults as: 60-90% of age-predicted

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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 disease 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 no handicapped people (5, 6, 7). The swain study showed that the fitness level is significantly affecting the relationship between exercise intensity indexes (8). A review on studies in this area is indicated 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. Therefore, the primary purpose of this study was to investigation and determines 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 also to examine the accuracy of the ACSM guideline for this population.

2. Methods

2.1. 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 (9). Before participation, each subject and their parents were informed of the purpose of study and the benefits and probable risks of the investigation and their parents signed an informed consent document to participate in the study. Participations were instructed not to engage in vigorous exercise the day before and the day of testing. They were also asked to refrain from eating 2 hr prior to testing. 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.

2.2. Testing protocol

All subjects performed the McMaster protocol (Submaximal and specific for children) (2) on an electronically braked cycle ergometer (Ergo Tunturi, E604. Finland). The test was preceded by a 2 minute warm-up period. A physician supervised each test. The protocol is performed in 4 stages. The initial power output was set at 12.5 W. The power output was then increased by 25 W 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.

2.3. Statistical analysis

After collection of the all data, relationship between these indexes calculated by regression in statically spss. Each stage value of HR and VO2 was expressed as a percentage of its maximum. Regression liner were performed for each of the individuals using paired data points from the end of each 2-minute Macmaster protocol stage and at maximum, with %VO2max chosen as the dependent variables. Using the individual liner regression, the percentage of HRmax corresponding to percentage of VO2max was determined for each of the subjects Regression analyses was conducted to determine correlation between these indexes.

3. Results

The purpose of the study was to compare the %VO2max versus %HRmax regression equations developed from data collected during exercise on an electronically braked cycle ergometer in adolescent with Dipelegia spastic cerebral palsy and comparison to ACSM equations. Means and standard deviations were calculated for age, height, weight and the physiological parameters measured during ergometery protocol. Descriptive statistic of these characteristics (means and standard deviations) and physiological measures of all participants are summarized in table 1.

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

variable	M	SD
Age (year)	12	2
Height (cm)	131	6.33
Weight (kg)	29.8	5.6
Rest HR (bpm)	81	5
Exercise HR (bpm)	163	7
Max VO2 (L.min)	1.51	0.12

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 percent HRmax (%HRmax) versus percent VO2max (%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).

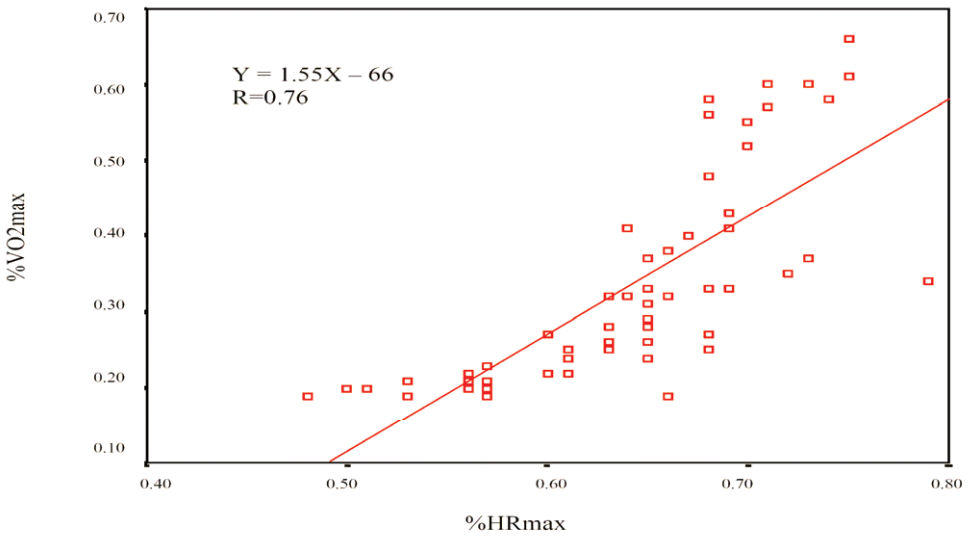

Figure 1. Regression of percentage of maximal heart rate %HRmax) versus percentage of maximal oxygen uptake (%VO2max)

4. Discussions and Conclusions

Physiological benefits gained from exercise training rely primarily on the intensity of the training stimulus. The prescribed intensity fraction can be alternatively applied using an absolute or relative approach. Absolute intensity is to prescribe a workload, such as 80 Watts on a cycle ergometer or a set caloric expenditure in a set time period (10). In this approach to intensity prescription, each person performing the set workload is under different physiological stress, *relative* to that person. Alternatively, exercise intensity is often prescribed by the relative physiological stress placed

upon the body. The relative intensity is usually determined as a percentage of a maximum capacity, such as maximal heart rate, maximum oxygen capacity (VO_2peak), or maximum exercise capacity (10). Subsequently, the target exercise intensity is prescribed by assigning a calculated value, which corresponds to a percentage of the particular maximum.

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. Perhaps the most important component, particularly in terms of safety and efficacy, is exercise intensity. In general, exercise intensity should be set at a level induces a training effect, but does not provoke abnormal clinical signs and symptoms (11). 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 (12, 13). Since heart rate is easy to measure and is linearly related to VO2, it is often used to monitor aerobic training intensity (2).

%HRmax method 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 (14). This variability is due partially to differences among individuals in resting HR (14). It is possible to estimate your exercise intensity as a percentage of VO2max from your training heart rate. These calculations are possible because of the liner relationship between HR and VO2 with increasing rates of work. Of course, Strath study suggested that after adjusting for age and fitness level, HR was an accurate predictor of VO2 (15).

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 and his research team has criticized the mathematical methods used to derive the regression equations in previous research (6). Using more correct statistical procedures, 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 affect equivalency between these exercise intensity indexes such as: age, fitness level, temperature, gender, cardiorespiratory fitness, mature, disease, drug, kind and extent of disease (10, 16, 17, 5). 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
(18)	Hui SS	%HRmax= 0.55 %VO2max+46.1	adolescent girls
(18)	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
(19)	Tolfrey K	%HRpeak = 0.681 × (%VO2peak) + 33.2	wheelchair propulsion
(5)	Simmons DN	%HRpeak = 0.55 × (%VO2peak) + 43.2	chronic obstructive pulmonary disease
(20)	Collins MA	%VO2max = 0.58 × (%HRmax) - 1.79	young males
(21)	Hellerstein	%VO2max= 1.41× (%HRmax) – 42	cardiac patients
(22)	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 (23). As is commonly, physical and physiological fitness of people with cerebral palsy is often lower than in the general population. When developing exercise guidelines for persons with cerebral palsy, it is important to consider secondary health conditions that may impact 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).

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 single 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 - %VO2max relationship and exercise intensity in the rehabilitation program for improving to cardiorespiratory fitness have to determine by directly for the people with each disease. One distinct possible reason for this discrepancy is influence of neuromuscular disturbance on cardiorespiratory or cardiopulmonary system that is better determining in the later study. Future research is needed in this population to determine the response of adolescent individuals with CP to difference

exercise intensity and the relation between these indexes. In addition, future studies are necessary to determine equivalency between these indexes in the each disease.

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