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Research article

Physiological cost index: comparison between repaired congenital heart disease and healthy children

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ABSTRACT

Children with congenital heart disease (CHD) have compromised physiological function compared to normal with the same age and anthropometric measure. Physiologic cost index (PCI) calculated the energy expenditure and gives an idea about the same during walking. So the present observational study calculates the energy expenditure in repaired congenital heart disease patient and provides the baseline for a goal to achieve during any rehabilitation program by comparing with the normal. To compare the PCI between repaired congenital heart disease patients and healthy children. The study design is observational. Total 40 participants were selected as per the criteria for inclusion and exclusion i.e. 20 healthy children and 20 with repaired congenital heart disease. Duration of the study will be for six months. The six-minute walk was performed according to guidelines, and PCI was calculated using the Macgregor's formula. In all the variables found of 6MWT, statically significant difference was seen. The mean values for PCI for repaired CHD group was 13.84 and for normal children it was 8.6 using the unpaired T test p value was found to be p=0.0001 which is statically significant. We can conclude that the energy expenditure in children with repaired congenital heart disease is more as compared to the normal children with similar age group. PCI can be used as an effective tool for a physiotherapist in assessment and evaluation of functional performance and provide the baseline for repaired CHD children.

Keywords: Physiological cost index, energy expenditure, six min walk test, congenital heart disease, Healthy children, PCI.

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INTRODUCTION

Every malformation has an impact on overall physiological functioning even after correction leading to impairment. These usually range from simple disorders that do not trigger signs of cyanosis and breathlessness to specific issues that trigger serious problems, endangering life. Congenital heart and vessel malformations occur in 5–8 per 1000 live births [1]. Resulting in an occurrence of around 0.7 percent. Some of these malformations (10–15 Percent) do not need correction. The key aims of recovery are to remove impairments, Disabilities, and disabilities, improve quality of life, and minimize disease-related morbidity, Post-operative disease [2].

Physical signs depend on the severity of the disorder which directly affects the physical function and quality of life. The spectrum of CHD is diverse. Shunt lesions, disorderly lesions, obstructive lesions, and complex lesions involved with the usual mixing and functioning of the single ventricles can be generally categorized as defects [3]. Type surgical operations are often undertaken in early childhood to reduce long-term problems stemming from aerodynamic pressure or recurring ankylosis [4]. Mortality related to the procedure was sub circumstantially reduced with improved techniques and experience. Ventricular septal defect (VSD) is the most common congenital heart disease in both sexes and has an incidence of approximately 20 percent in children with heart defects. Ventricular septal defects can occur in a variety of places and sizes [5]. The ventricular septum is made up of different types of tissue, with one section made up primarily of muscle and the other of thinner, fibrous tissue. The ventricular septal defect's implications will be determined in part by the location and size of the hole within the septum. VSDs rarely get larger and instead become smaller or identical. This reason is that when a baby is identified with a ventricular septal defect, most cardiologists do not recommend immediate surgery, but instead examine the baby closely and seek medicine to treat the symptoms of congestive heart failure to see if the defect resolves on its own. Also with less severe heart defects, there is a deficiency to an uncertain degree at the moment [5]. This is the reason for CHD rehabilitative

treatment aimed at a long-term reduction of morbidity and an improvement in the patient's quality of life. Given the financial expenditure currently being directed at intrusive therapeutic measures, it is justifiable to increase the time and money spent on improving the quality of life of this patient community by implementing effective rehabilitation steps in a timely manner [6].

Walking is the basic and main component of activity in daily living. The human body is designed to be in motion against gravitation. This requires optimum functioning of all body system to meet the desired energy demand considering heart at the center to supply by its pumping action. [7]Total energy expenditure is the amount of energy a human uses to perform a basic bodily process such as breathing, pumping blood, digest food or daily energy expenditure for physical activity is the overall number of calories spent each day.

Macgregor introduced the Physiological Cost Index (PCI) a simple, practical, non-invasive method of measuring the physiological cost of walking in domestic as well as in clinical environments [1]. He also suggested PCI is one of the good energy cost indicators. The PCI is easy to use, accurate method carries some objectivity in evaluating and measuring functional efficiency Six-minute walk test is a submaximal exercise test used to calculate PCI. Patients with congenital heart disease has reduced exercise capacity on submaximal test thus PCI can also help to evaluate the energy cost [8].

The PCI is an easy to use objective and accurate energy use test and is recommended as a helpful method for physiotherapist in evaluating and measuring functional efficiency. Macgregor's suggested Physiological Cost Index (PCI) is measured as the quotient of the difference in heart rate and walking rate of work and rest [9]. The worth of PCI represents peak rate of the heart that is needed to hike and is measured for each unit with heartbeats.

The total energy expenditure is the amount of energy required for a person to accomplish a physical function such as breathing, pumping blood, digesting food, or a daily energy expenditure for physical activity is the total number of calories expended each day.

Congenital Cardiovascular Disorder, and cardiomyopathy disease, is perhaps a cardiovascular disease or defect prominent at childbirth. It mainly affects walls and valve of the heart and the blood canisters. However there are a variety of different of styles of congenital cardiac disease [7]. These usually range from simple disorders that do not trigger signs to specific issues that trigger serious problems, endangering health issues. Physical signs depend on the severity of the disease. Some defects may have 1 or 2 symptoms or asymptomatic. Symptoms are: Blue or purple-tinted nails or lips, Fast or disturbed respiration, fatigue. Congenital Heart Disease is a condition present since birth having malformed heart structure and function [9]. The malfunction of the heart hemodynamics requires palliative, supportive and corrective surgery. Children with congenital heart disease have compromised physiological function compared to normal with the same age and anthropometric measure [10]. The energy consumption for a given submaximal work would be more in CHD patients compared to normal. Physiologic cost index calculated the energy expenditure and gives an idea about the same during walking. PCI can be used as an outcome measure to plan and tailor a rehabilitation exercise program. Types of CHD are Patent ducts arteriosus (PDA), Atrial septal defect (ASD) , Ventricular septal defect (VSD), Atrio-ventricular canal (AVC), Tricuspid atresia ,Pulmonary atresia, Tetralogy of Fallot, Coarctation of the aorta (CoA), Aortic stenosis (AS) [11].

Submaximal 6-min walk test is a cost-effective, reasonably plain and quick, safe, popular with highly-tolerated method of testing practical exercise ability. 6-Minute Walk Test comprise of accurate, fairly fast, safe, and well-tolerated technique for assessing the functional exercise ability of patients in mild to serious cardiomyopathy or respiratory obstructions [12].

As 6MWT is safer, quicker to prescribe, well-handled and indicates improved daily life compared with many casually walking exercises (such as a shuttle trip test). The key metric is a 6-min walking distance (6MWD), since blood oxygen saturation and dyspnea perception when under exhaustion may also be obtained during the 6MWT results [13].

METHODOLOGY

The research was conducted in Acharya Vinoba Bhave Rural Hospital and School of scholars, Sawangi(Meghe). The study type is observational with purposive sampling with sample size 40. The study duration is 6 months. Inclusive criteria include children with Repaired CHD and healthy children with age group 6-18years who can perform the 6MWT. Exclusion criteria includes children above or below the required age group, haemodynamically unstable and children not willing to participate.

Ethical approval was obtained from the institutional ethical committee. Subjects were a part of the study as per the inclusion and exclusion criteria. Consent was obtained from the relatives. Group A with repaired CHD while Group B with healthy children. The subjects will be evaluated thoroughly and explained properly about the study. Six-minute walk test will be conducted as per the guidelines to calculate PCI along with other standard variables.

The PCI will be measured using the formula: PCI = [Mean HR at work – Mean HR at rest] / [Walking speed (m/min)]

Procedure

The Institutional Ethics Committee (IEC) Clearance was be obtained prior. Students were selected as per the inclusion and exclusion criteria that has been mentioned. The participants were

oriented about the aim of the research and about 6MWT. The consent was taken from all the participants and 6MWT was performed in 30 m walk way Pre and post variables of 6MWT were taken and using the Macgregor's formula, the PCI was calculated. After that the data collection was done and statistical analysis was obtained.

RESULTS

Statistical analysis was done by using descriptive and inferential statistics using Student's unpaired t test and software used in the analysis was SPSS 27.0 version and $p<0.05$ is considered as level of significance.

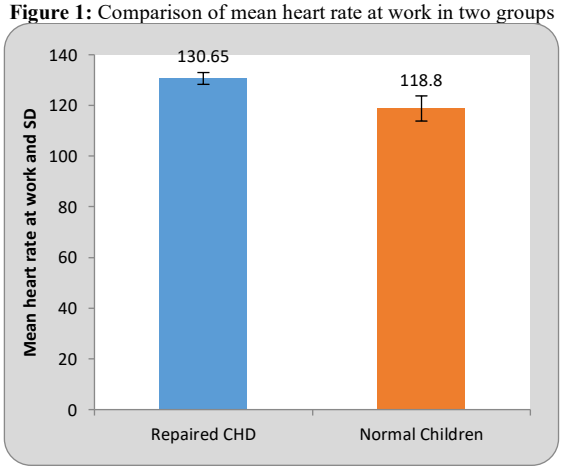
To find out the PCI 6MWT was taken. In all the variables found of 6MWT, statically significant difference was seen. The mean values for PCI for repaired CHD group was 13.84 and for normal children it was 8.6 using the unpaired T test p value was found to be p=0.0001 which is statically significant. So we can conclude that the energy expenditure in children with repaired congenital heart disease is more as compared to the normal children with similar age group.

Table 1: Comparison of mean heart rate at work in two groups

Group	N	Mean	Std. Deviation	Std. Error Mean	t-value
Repaired CHD	20	130.65	2.33	0.52	9.67
Normal Children	20	118.80	4.95	1.10	p=0.0001,S

The above table depicts that the mean heart rate at work for repaired CHD group is 103.65 and for Normal children it is 118.8. Using the unpaired T test p value was found to be p=0.0001 which is statically significant

Figure 1: Comparison of mean heart rate at work in two groups



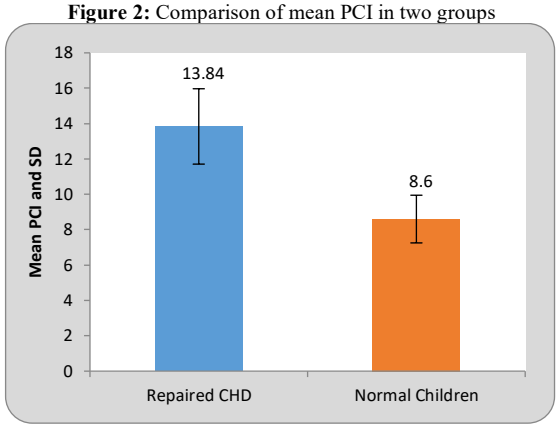
In this graph the mean heart rate at work for repaired CHD group is 103.65 and for Normal children it is 118.8. Using the unpaired T test p value was found to be p=0.0001 which is statically significant.

Table 2: Comparison of mean PCI in two groups

Group	N	Mean	Std. Deviation	Std. Error Mean	t-value
Repaired CHD	20	13.84	2.13	0.47	9.27
Normal Children	20	8.60	1.35	0.30	p=0.0001,S

The above graph depicts that the mean PCI of Repaired CHD children in 13.84 and for normal children it is 8.6, using the unpaired T test p value was found to be p=0.0001 which is statistically significant.

Figure 2: Comparison of mean PCI in two groups



The above graph depicts that the mean PCI of Repaired CHD children in 13.84 and for normal children it is 8.6, using the unpaired T test p value was found to be p=0.0001 which is statistically significant.

DISCUSSION

The study aims at evaluation and comparison of PCI in repaired CHD and healthy children. Two groups were made, group A consisted of 20 repaired CHD children while group B consisted of 20 school going healthy children [14]. After the consent taking the 6MWT was performed according to the guidelines. The resting heart rate was taken using the heart Rate monitor which was attached around the chest. After noting down the resting HR, the child was made to sit in silence and preceding HR was taken after 5mins. The walking was conducted inside in walk way type of corridor [15]. They were made to walk at their chosen velocities over three consecutive lengths, for a total distance of 30m. The time it took to walk the distance was measured. The heart rate was taken at the end of the walk, indicating that previous values are available [16]. After that, the child was allowed to relax until his heart rate returned to normal. Walking speed and heart rate were constantly monitored, and post-test values were taken. The physiological cost index (PCI) was determined for each child based on their walking speed and heart rate [17].

This information can be used to make treatment decisions that result in improved quality of life and functional capacity. Children with congenital cardiac anomalies typically, they have a reduction in functional capacity [18]. This occurs in the preoperative, postoperative, and long a period contexts, and may be the result of the original cardiac issue, therapy of that issue, or hypoactivity leading to detraining [19]. Cardiopulmonary exercise testing (CPET) provides precise information about the heart, lungs, and peripheral muscle function.

The primary purpose of exercise testing in children is to evaluate physical ability for recreational, athletic, and professional recommendations, as well as to evaluate specific pathophysiological aspects, assesses the functional postoperative success, triggers for further exercise and weight loss. PCI is the simple, easily available tool does not require extra expertise to estimate the energy expenditure.[20]

CPET requires standard-setting and infrastructure to evaluate the cardiorespiratory endurance and energy expenditure. Thus, the purpose of the present study is to evaluate the energy expenditure using PCI in congenital heart disease children and how much difference will be found in comparison to normal children. PCI will calculate the energy expenditure that occurs during functional activity [15].

The mean values for PCI for repaired CHD group was 13.84 and for normal children it was 8.6 using the unpaired T test p value was found to be p=0.0001 which is statically significant. So we can conclude that the energy expenditure in children with repaired congenital heart disease is more as compared to the normal children with similar age group [16].

Similarly, In the Population Of children 6 to 18 Years Swati A. and others conducted a study in which the kids of spastic diaplegic CP showed increased cost of energy and slower walking speed compared to normal children with slow walking speed. In this study they concludes that walking with orthoses showed higher cost of energy and slower speed compared to normal children in spastic diplegic CP children. In spastic Diplegic cerebral palsy children the PCI of walking is less than without orthosis, i.e. gait is more energy efficient with orthosis. BMI shows no further link with PCI research. Secondly, Kavitha Raja and coworkers did a study to assess if the PCI may be used as a reliable index of gait efficiency and an assess of the outcome of cerebral palsy [20]. After three different distances, PCI was computed (50, 100, and 150 m). A manual pulse recording calculated the PCI of the healthy children and children with CP, with kids walking 50 m in inside and 50 m on uneven outside surfaces. The mathematical reproducibility of PCI has been assessed. Each patient's PCI value was compared to the respective functional mobility score [2]. PCI has been calculated before and after a therapeutic procedure in a group of youngsters with CP. The PCI readings were compared to both cardiac measuring methods and walked for 3 kilometers. The study showed that the lower the functional mobility values, the higher the PCI values [19]. They found that PCI can be utilized as a valid gait efficiency metric in pediatric patients with CP. Thirdly The aim is to examine the reliability and validity of the PCI values, as a marker of the energy expenditure, when healthy volunteers follow 2 separate lines in the field. Rachel Graham and Others White did a study (20-m and 12-m figure eight tracks). The study led to Correlations with PCI were weak between VO2 and EO2. The 20-m path PCI results were considerably lower than the 12-m path scores. They observed that the PCI is dependable but does not quantify the energy costs of walking on either track in healthy participants. For clinical applications, the 20-m trail is preferred since it allows patients to move quickly. Many studies have evaluated functional performance in patients with coronary artery disease and there is the paucity of studies in repaired congenital heart disease, so the present study aims at evaluation and comparison of PCI in repaired CHD and healthy children [21].

CONCLUSION

The result of this study indicates that the energy expenditure in children with repaired congenital heart disease is more as compared to the normal children with similar age group. PCI can be used as an effective tool for a physiotherapist in assessment and evaluation of functional performance and provide the baseline for repaired CHD children. Physical activity in congenital heart disease patients is reduced as compared to their counterparts because of the deviation in normal structure, functional and dynamic of heart, defects that reduce the cardio-respiratory endurance even after the repair. The cost energy expenditure for particular activity found to be more in repaired CHD patients. The further study will be needed with large sample size to evaluate the in detail the haemodynamic response and overall energy expenditure in CHD patients for any activity in Repaired CHD patients. Even after the repair, the prolong reduce activity level secondary to disease affects the Cardiopulmonary Endurance.

Limitations

The sample size is small due to limited study duration. The literature on current topic is limited to discuss.

Ethical clearance

Institutional Ethics Committee (IEC) of Datta Meghe Institute of Medical Sciences, Deemed to be University, Sawangi (Meghe).

Conflict of interest: None

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