RESEARCH ARTICLE

A COMPARATIVE STUDY OF PHYSIOLOGICAL COST INDEX IN CP AND NORMAL CHILDREN ON TWO DIFFERENT SURFACES

*,1Dr. Nikita Patel and 2Dr. Manoj Kumar

*,1C. M. Patel College of Physiotherapy, Gandhinagar; 2Shree B.G. Patel College of Physiotherapy, Anand.

ABSTRACT

To compare energy expenditure of ambulation on even indoor and uneven outdoor surface in CP children as well as between CP and asymptomatic children. **Objective:** To find out and compare physiological cost index on even indoor and uneven outdoor surface during walking in spastic CP and asymptomatic children. To correlate gross motor function and PCI. **Method:** 30 CP children and 30 asymptomatic children between 3 to 17 years walked for 6 minute on indoor even and uneven outdoor surfaces. Their energy expenditure was measured by physiological cost index. **Results:** Independent 't' test and paired 't' test were used for analysis. There was statistically significant difference between normal and CP children also between indoor even and outdoor uneven surfaces. Indoor performance better than outdoor performance under both conditions. **Conclusion:** children with CP having more energy expenditure than normal children on both surfaces.

INTRODUCTION

"CP is a group of permanent disorders of development of movement and posture causing activity limitations, attributed to non progressive disturbances that occurred in the developing fetal or infant brain." (Susan and Rethlefsen, 2010). The incidence of Cerebral palsy (CP) is up to 3 cases per 1000 live births in India (IACP, 2011). The prevalence of CP is the range of 1.5 to 2.5 per 1000 live births (IACP, 2011).

CP is also commonly associated with a spectrum of developmental disabilities, including mental retardation, epilepsy, and visual, hearing, speech, cognitive, and behavioral abnormalities and locomotion. Although the disorder is non-progressive, bio- mechanical changes occur as the child grows because of muscle shortening, muscle weakness and lack of motor control in the affected limbs. These changes can lead to balance de cits, decreased cardio respiratory fitness and decreased strength all of which may lead to functional impairment (Mulligan, 2004). Normal walking requires balance, propulsion, shock absorption and energy consumption. CP children affect these factors because of tone abnormality, altered muscle performance and posture abnormality (Dobson F, Morris ME, Baker R, *et al* 2007, 'Gait classification in children with cerebral palsy: a systematic review.' Gait

Posture. 25(1):140-52). Because of all these factors present in CP children, there is increase energy expenditure in these children. So, energy expenditure is important measure for more efficient functional evaluation & effectiveness of intervention. Aerobic metabolic pathways are the major energy supplier for prolonged muscle activities. So, energy expenditure occur and oxygen consumption is closely related to energy expenditure. Mac Gregor (1979) developed the Physiological Cost Index (PCI) for measuring the energy expenditure of walking. Rose *et al* found a linear relationship between Heart Rate (HR) and oxygen uptake. Raja *et al.* (2007) concluded that PCI can be reliably calculated without the use of any instrumentation beyond a stopwatch & can be used as a measure of ambulatory function with other functional measure from the study including 100 normal children aged between 7 and 15 years and 227 children with CP aged between 5 and 16 years who could ambulate 50 meters without human assistance (Raja *et al.,* 2007). Jaya Shanker Tedla and Kavitha Raja *et al.* (2011) conducted a study on 25 spastic diplegic CP children with age between 5-17 years walked for 50 meters on indoor even and outdoor uneven surfaces with and without walker. Their energy expenditure was measured through physiological cost index and concluded that children given better indoor even surface performance than outdoor uneven performance and required more energy when ambulating through walker than independently or hand hold support (Jaya Shanker Tedla and Kavitha Raja *et al.*, 2011). Need of study is to find out energy

*Corresponding author: Dr. Nikita Patel
C. M. Patel College of Physiotherapy, Gandhinagar

expenditure during walking on different surfaces by PCI in CP children and compare it with asymptomatic children of same appropriate age. Aim of study is to evaluate the physiological cost index in CP children during walking on even indoor and uneven outdoor surface and compare it with asymptomatic children. Objectives of study are To find out and compare physiological cost index on even indoor and uneven outdoor surface during walking in spastic CP and asymptomatic children, and to correlate gross motor function and PCI.

METHODOLOGY

A cross sectional study was done, consisting of 60 children out of which 30 CP children and 30 asymptomatic children with convenient sampling method at Department of Pediatric Physiotherapy, SHRI B.G.PATEL COLLEGE OF PHYSIOTHERAPY, ANAND, Anupam mishan school, Mogri, Brahmjyot school, Mogri. Those with age between 3 to 16 of both genders, able to follow 2- 3 steps commands , with GMFCS level 1,2,3, able to walk 6 minutes independently or with one hand support and with assistive device and those having Co-morbid health conditions, Surgery, Botox for lower limb muscles within past 6 months ,severe behavior , visual and perceptual problem ,uncontrolled seizure disorder were excluded. For study 40 subjects with CP and 30 healthy individuals were taken, subjects selected on basis of inclusion and exclusion criteria & then, only 30 subjects of CP were recruited. All parents or guardians provided written informed consent. Resting heart rate was measured. Subject was made to sit quietly for 5 minutes on a seat. Procedure explained to parents and guardians. Subject was made to walk for 6 minutes & distance was measured. Subject made to sit after walk and heart rate was measured for first 15 seconds, following which PCI was measured through equation. PCI was calculated using this formula including a data measure from 6MWT carried out on even (indoor) and uneven (outdoor) surface for both population. (4,8,14,16,17,18,19)

$$PCI \text{ (beats/metre)} = \frac{\text{Final Heart Rate} - \text{Resting Heart Rate}}{\text{Speed of walking}}$$

Test 1: PCI determined with above procedure on indoor even surface in Group -A.
Test 2: PCI determined with above procedure on outdoor uneven surface in Group-A
Test 3: PCI determined with above procedure on indoor even surface in Group-B.
Test 4: PCI determined with above procedure on outdoor uneven surface in Group-B.

Outcomes :

1) **PCI**

The physiological cost index (PCI) is a clinical tool thought to indicate the energy expenditure, physiologic cost and effort of walking (Sienko Thomas *et al*., 1996; Steven *et al*., 1983; Waters, 1999). Originally devised by MacGregor, the PCI was designed to assign a physiologic cost to physical performance over a 24 hour period. It assumes a linear relationship between oxygen consumption (VO2) and heart rate at submaximal levels (Waters, 1999) and therefore uses heart rate as an indicator of energy expenditure. The original design was

quickly adapted to laboratory based clinical assessments which typically require the subject to walk for less than 10 minutes. Because minimal equipment is used to administer the PCI, it is proposed as a feasible low-cost, low technology alternative to the use of gas and calorimetric analysis equipment during gait analysis, which may be impractical or unavailable in clinical departments. Subjects walk at their preferred pace, usually following a track of known distance, while heart rate and time are noted. After measurement of resting heart rate, a person's PCI in beats per meter is calculated using the following equation (Waters, 1999).

$$PCI \text{ (beats/metre)} = \frac{\text{Final Heart Rate} - \text{Resting Heart Rate}}{\text{Speed of walking}}$$

The test-retest reliability of the PCI has been reported as high (intraclass correlation coef cient 0.92) (Waters, 1999).

(2) GMFM-88

- The GMFM developed for children with CP.
- The test includes 88 items including five dimensions

(1) lying, (2) sitting (3) crawling and kneeling (4) standing (5) walking

The test found intraobserver reliability for each dimension and total score to range from 0.92 to 0.99 and interobserver reliability to range from 0.87 to 0.99[15]

Statistically analysis
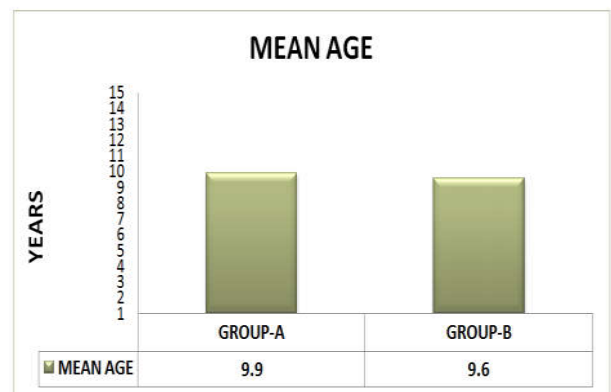
Group A= CP children
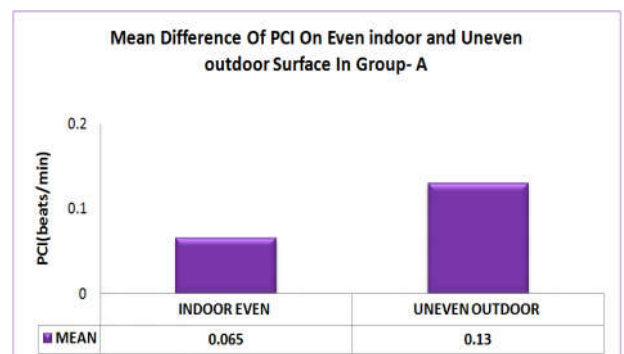Group B= Asymptomatic children

Fig. 1. Demographic data

Fig. 2. Comparison between even indoor and uneven outdoor surface PCI value in group –A by paired t-test.

- At 99% confidence interval = -0.09351 to -0.03116
- In this test 't' calculated value > 't' tabulated value
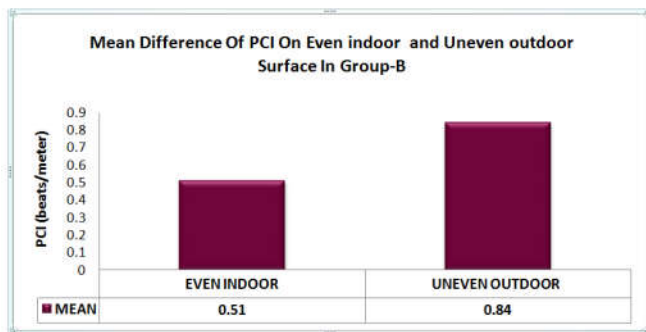

Fig. 3. Comparison between even indoor and uneven outdoor surface PCI value in group-B by paired t-test.

- At 99% confidence interval = -0.5522 to -0.09317
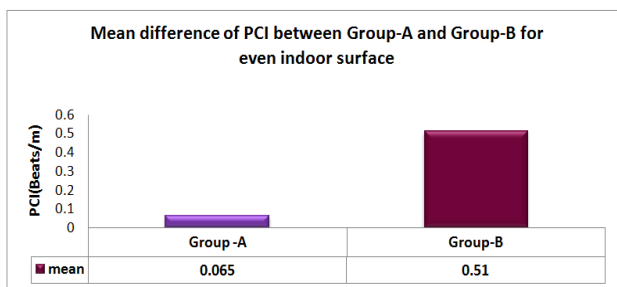- In this test 't' calculated value > 't' tabulated value

Fig. 4. Comparison of PCI between group- A and group- B on even indoor surface by unpaired t-test.

- At 99% confidence interval = 0.2961 to 0.6005
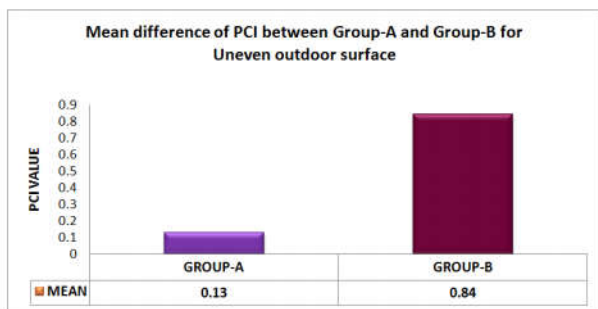- In this test 't' calculated value > 't' tabulated value

Fig. 5. Comparison of PCI between group- A and group –B on uneven outdoor surface by unpaired t-test.

- At 99% confidence interval = 0.4666 to 0.9508
- In this test 't' calculated value > 't' tabulated value

Correlation between PCI and GMFM score in Group- B

- Pearson correlation coefficient(r) = -0.4289
- At 99% confidence interval = -0.7418 to 0.03735
- There was negative correlation. So, this study is significant.

DISCUSSION

The results of present study showed that markedly increased energy expenditure in form of physiological cost index in CP patients than normal children in respect to both even & uneven surface. Comparison of PCI between group-A and group-B on even indoor surface at 99% confidence interval showed that PCI of group-B statistically significant increased than group-A.

The reason behind probably this the potential differences across 2 groups might include in CP children due to the loss of selective motor control, impaired balance, abnormal tone, weakness, and affected range of motion contribute to the lower mechanical efficiency during ambulation. In addition to the decreased mechanical efficiency, fatigue may be reflective of a reduced metabolic capacity at the muscle level which may be reflected by energy expenditure. Lower extremity muscle co-contraction or spasticity while walking might increase energy expenditure by causing the displacement of the center of gravity to vary, leading to a less efficient walking pattern (Mann 1983, Gage 1993). And also alterations in segmental energy transfer might contribute to increased energy expenditure because children with CP use atypical patterns of movement, which might interfere with the natural exchange or transfers of potential and kinetic energy between body segments. It has been shown that these de cient energy transfers account for as much as 87% of the variability in the energy cost of walking for children with CP. Kramer and Mac Phail (1994) found that knee extensor strength was related to energy expenditure which was less in spastic CP child (Kramer, 1994).

Rose *et al* concluded that the EEI values for diplegic children were 3 times higher than those for hemiplegic children (Ade ´laBde van den Hecke, and Christine Malghem, 2007). Comparison of group-A and group-B on uneven outdoor surface at 99% confidence interval showed group-B statistically significant increased than group-A. Comparison of PCI between even indoor and uneven outdoor surface in Group-A at 99% confidence interval showed that on uneven outdoor surface PCI value somewhat higher than even indoor surface. Reason behind that showed according to Raja Kavitha *et al.* (2007) that normal children, 10% greater PCI values were noted when they walked outdoors. The data of this study correlate with my present study.

Comparison of PCI between even indoor and uneven outdoor surface in Group-B at 99% confidence interval showed that on uneven outdoor surface PCI value was significantly higher than even indoor surface. Reason behind this probably was due to physical condition or due to environmental barrier or because of lack of practice. From result found that there was negative correlation between GMFM (gross motor function) and PCI in CP children. So, result shows that in CP children PCI was increased and GMFM score decreased. It was inversely proportional to each other in CP.

Limitation of study: Sample size was relatively small. Study consisted of all variety of spastic CP like hemiplegic, diplegic, triplegic and quadriplegic. Differences, if any, that might exist between genders were not able to be adequately addressed. Severity of involvement of patients was dissimilar.

Future study: To check out the difference between hemiplegic and diplegic spastic CP. To give intervention and will measured with PCI as a clinical outcome measure.

Conclusion: There was energy expenditure in form of PCI increased during walking in CP children than normal individual. There was energy expenditure in form of PCI

increased in CP children on outdoor uneven surface than indoor even surface.In this present study, null hypothesis is rejected and alternative hypothesis is accepted.

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Conflict of interest: None

Ethical clearance: Study was approved by Institute Ethics Committee- Shree BG Patel College of Physiotherapy, Anand.

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