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Original Research Article

Comparative study of the Physiological Cost Index of walking among healthy children and children with impairments of upper limb and lower limb

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Abstract

Introduction-An increase in physiological cost index of walking due to gait abnormality resulting from impaired lower limb function is known but there is paucity of literature regarding the affection of physiological cost index of walking due to dysfunction of upper limb. Hence the need of the study. **Methods**-It was a cross-sectional, comparative, observational, pilot study, conducted in the physiotherapy out-patient department of a government tertiary care hospital.15 participants were recruited in each of the three groups namely healthy normal children, children with lower limb impairments and children with upper limb impairments. They were instructed to walk for 55 meters, prior to and after which the heart rate was measured and the values were substituted in the formula of physiological cost index of walking. **Results-** The difference in physiological cost index of walking between the healthy normal children and children with lower limb impairments and between healthy normal children and children with upper limb impairments was statistically significant ($p < 0.001$). But the difference in physiological cost index of walking among children with upper limb and lower limb impairments was not statistically significant. ($p = 0.3245$). **Conclusion**- Thus it is concluded that physiological cost index of walking is similarly affected in children with upper limb and lower limb impairments.

Keywords : Original research article, Physiological Cost Index, Upper limb impairments.

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Introduction

Human gait is bipedal with alternate associated movements of upper limbs.[1]Gait not only includes lower limb and pelvic interactions but also alternate associated arm swing. There are six determinants of gait viz pelvic rotation, pelvic tilt, knee and hip flexion, knee and ankle interaction, and lateral pelvic displacement.[1,2] If there is an affection of any of these components, there is a substitution strategy that is developed to compensate for the lost determinant, thereby increasing the energy expended as compared to normal. Similar to these lower quadrant strategies of human body which optimise gait, arm swing too has been hypothesized to have an effect on gait stability.[3]

Physiological cost index (PCI) is one of the most inexpensive methods which can be utilised in an average physiotherapy department to determine the energy expenditure with good test-retest reliability (r=0.843-0.944) in steady and unsteady states.[4] It is a good correlation of oxygen cost.[5] Also, Butler et al states that the physiological cost index of walking is a valuable indicator of level of handicap in children.[6]

An increase in physiological cost index of walking due to gait abnormality resulting from impaired lower limb function in children[7] is known but there is paucity of literature regarding the affection of physiological cost index of walking due to dysfunction of upper limb. Hence the need of the study.

Research question

Will children with impairments of upper limb have an affection in the physiological cost index of walking as compared to children with lower limb abnormalities and healthy normal children?

Objectives

To compare the energy expenditure of walking using the formula of physiological cost index (Mac Gregor et al, 1979) among three groups viz healthy normal children, children with musculoskeletal and neurological impairments of upper limb and children with musculoskeletal and neurological impairments of lower limb.

Methodology

Study Design

It was a cross-sectional, comparative, observational, pilot study, conducted in the physiotherapy out-patient department of a government tertiary care hospital. A purposive sampling technique with complete enumeration method was used for the recruitment of the patient. There were three groups with 15 participants each in the age group of 5-15 years of either gender who were willing to participate in the study. The first group consisted of ambulatory children with musculoskeletal or neurological lower limb impairments or abnormalities with or without walking aids. The second group was of ambulatory children with musculoskeletal or neurological upper limb impairments or abnormalities. The third group included healthy normal children who accompanied patients in the study centre. Any participant with cognitive impairments were excluded from the study. The study was approved by the local Departmental Review Board. Written informed assent and consent was taken from the participant.

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Study Procedure

The participants were asked to relax for 5 minutes after which their basal heart rate was recorded. Then the participants were instructed to walk for 55 meters in a hallway (McKellar et al)[8] at their own comfortable pace and the time to complete the stipulated distance was noted. Heart rate was noted immediately post walk and all the readings were substituted in the formula.[6, 8]

$$\text{PCI (beats/meter)} = \frac{\text{(Post Walking HR- Resting HR in beats/min)}}{\text{Gait Speed in meters/min}}$$

Statistical Analysis

Data was not normally distributed as per the Shapiro Wilks test. Two-two groups were being compared at each time. Hence non parametric Mann Whitney test was used to compare the physiological cost index of walking amongst the groups instead of ANOVA which is for three groups together.

Results

The participants in the group with upper limb impairments constituted 13 male children and 2 female children.

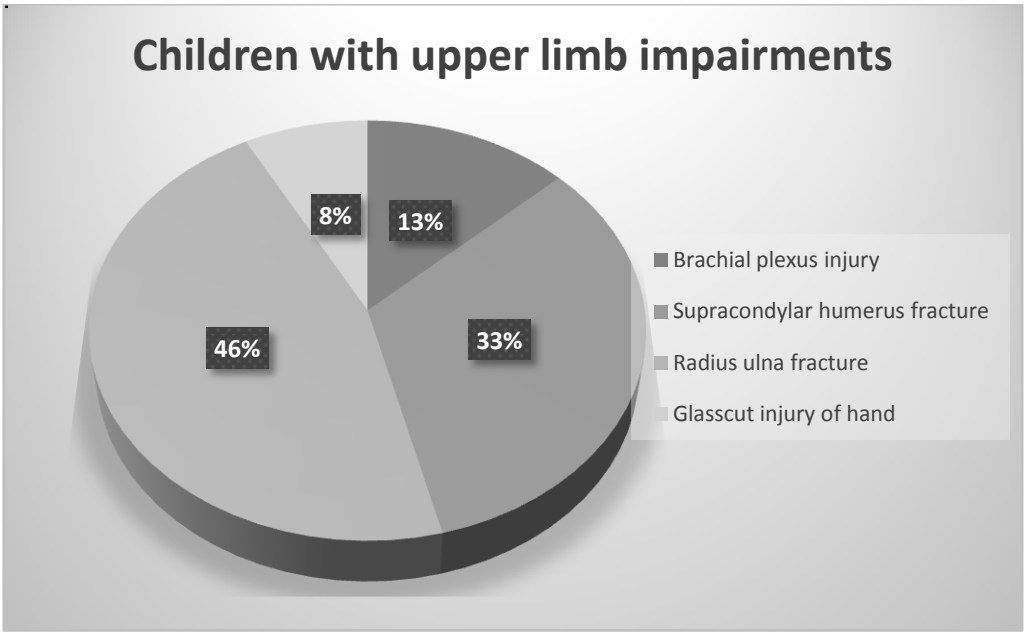

Figure 1: Percentage of each impairment in the group having upper limb impairments.

The participants in the lower limb impairments group constituted 10 male children and 5 female children.

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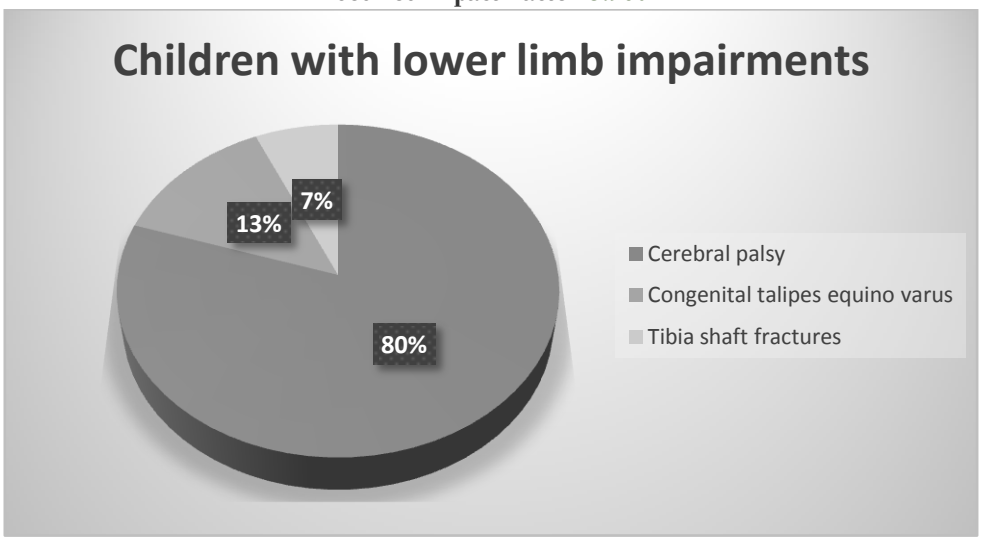

Figure 2: Percentage of each impairment in the group having lower limb impairment

The participants who were healthy and normal had 12 male children and 3 female children.

Table 1: Comparison of PCI of walking among healthy normal children and children with lower limb impairments.

	Healthy Normal Children (beats/meter)	Children with lower limb impairment (beats/meter)	P value
Mean	0.2061	0.6448	<0.0001 Statistically Significant
SD	0.0485	0.3346	
Lower 95% CI	0.1792	0.4595	
Upper 95% CI	0.2330	0.8302	

Table 2: Comparison of PCI of walking among healthy normal children and children with upper limb impairments

	Healthy Normal Children (beats/meter)	Children with upper limb impairment (beats/meter)	P value
Mean	0.2061	0.4862	<0.0001 Statistically Significant
SD	0.0485	0.1718	
Lower 95% CI	0.1792	0.3910	
Upper 95% CI	0.2330	0.5813	

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Table 3: Comparison of PCI of walking among children with lower and upper limb impairments

	Children with lower limb impairment (beats/meter)	Children with upper limb impairment (beats/meter)	P value
Mean	0.6448	0.4862	0.3245 Not Significant
SD	0.3346	0.1718	
Lower 95% CI	0.4595	0.3910	
Upper 95% CI	0.8302	0.5813	

Discussion

As shown in Table 1, there was statistically significant difference in physiological cost index of walking among healthy normal children and children with lower limb impairments. This is in consensus with previous studies done on children with cerebral palsy, using ankle foot orthosis due to lower limb impairments, where they found an increase in the physiological cost index of walking.[7] As shown in Table 2, there was statistically significant difference in physiological cost index of walking among healthy normal children and children with upper limb impairments. This is in accordance with studies which have previously stated that synchronized swinging of arms provide counterbalancing to the forward swinging of the leg and helps to decelerate rotation of the body which is imparted to it by the rotating pelvis. Arm swing help in reducing the vertical moments generated.[3,9] In the absence of arm swing there is an increase in the in the vertical moments that need to be counteracted hence increasing the energy expenditure. With reference to Table 3, there was no statistical significance between the groups having upper limb and lower limb impairments. Just like alteration in lower quarter gait determinants lead to increase in the energy cost due to wide displacement of centre of gravity as an attribute to an increase in muscle work,[7] likewise absence or reduction of arm swing which is also an important but neglected aspect of human gait leads to a similar outcome.

Normal swinging of the upper extremity maybe lost in children with upper limb trauma either due to pain, apprehension or weakness post fracture and the experience of inducing incident.[10] Their guarded gait with the mere reduction or absence of arm swing increases the oxygen cost of walking.

Conclusion and clinical application

The study indicates the less studied fact that the physiological cost index of walking is significantly increased in children with movement dysfunction not only of lower limbs but also of upper limbs and that it is affected to a similar extent in upper limb and lower limb impairments. Thus it implies that in the rehabilitation phase of upper limb movement dysfunction, consideration has to be given to retrain the associated movements of upper extremity to optimize the energy consumption which the patient may not do due to apprehension.

Study limitation

The matching was not done on the basis of gender of the children in the three groups. Also the groups were non homogenous with different injuries of upper limb and lower limb and varying levels of disability. Thus there is scope for further studies with a larger sample.

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