International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2019): 7.583

Effect of Spasticity on Gait Parameters and Physiological Cost Index in Patients with Spastic Cerebral Palsy

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Abstract: ***Purpose: To investigate if the effect of tonal abnormality in hamstring and TA muscles measured with Modified Tardieu Scale affects the spatial parameters of gait and Physiological Cost Index. Methods: The evaluation was carried out on 5 spastic cerebral palsy patients of age between 4 to 15 years. Measurements used were Physiological cost index, Gait parameters which included stride length, step length and walking speed and Modified Tardieu scale was used to measure spasticity of hamstring and TA muscles. Results: The gait parameters and physiological cost index relatively showed significantly lower values in the cerebral palsy children. Conclusion: The study concluded that tonal abnormality in lower limb may lower the values of gait parameters as well as physiological cost index in children with Cerebral palsy.***

Keywords: Spastic cerebral palsy, Spasticity, Gait parameters, Physiological Cost Index

1. Introduction

Cerebral Palsy is described as a group of permanent disorders of the development of the movement and posture which causes activity limitation.[1] The motor disorders of cerebral palsy are often accompanied by the disturbances of sensation, perception, cognition, communication, behavior, by epilepsy and by secondary musculoskeletal problems. Cerebral Palsy is characterized by motor dysfunction due to non-progressive brain damage early in life. There are many causes of the brain damage, including abnormal development of the brain, anoxia, intracranial bleeding, excessive neonatal asphyxia, trauma, hypoglycemia and virus and other infections.[2]

Cerebral palsy is leading cause of childhood disability. The incidence of cerebral palsy is approximately 2 to 3 cases per 1000 live birth around the world.[3] Cerebral palsy has been classified based on the type of movement disorder as spastic, athetoid, ataxic, and mixed and based on the area of the body involved as hemiplegia, diplegia, quadriplegia.[4] In Cerebral palsy the lesion in the central nervous system frequently results in spasticity of various muscle groups. Spasticity is defined as a velocity dependent resistance to stretch. Spastic Cerebral palsy is caused by damage to the pyramidal parts of the brain.[1] The changes in bone and joint in cerebral palsy results from muscle spasticity and contracture.

The children with spastic diplegia frequently experience problems with motor control, spasticity, and balance which may lead to gait abnormalities.[5] The abnormal gait patterns in spastic diplegia is associated with the following symptoms such as increased muscle tone, a loss of muscle control, deficient equilibrium reactions and relative imbalance of muscle forces across the joints in the lower extremities.[5] Because of motor weakness and poor voluntary motor control the children with spastic diplegic cerebral palsy develop crouch gait or diplegic gait. Crouch gait is a common pathological walking pattern adopted by individuals with cerebral palsy that is characterized by excessive hip and knee flexion.[5] Spatiotemporal parameters are often used to evaluate gait development in children and to identify potential disorders. In addition, gait in children with Cerebral palsy is characterized by a slower walking speed, a shorter-stride length, and more time spent in double support. Usually children with spastic diplegic cerebral palsy leads to decreased physical activity which may be related to gait capacity. [6]-[15] These features may influence quality of life of children with Cerebral palsy by reduction of daily life activities and independent mobility.[6]

Children with Cerebral palsy have their individual gait pattern with numerous variations which is mainly characterised by increased tone and hyperflexion of muscles. Muscle weakness is one of the most important components in children with cerebral palsy which co relate with gait speed and locomotor ability.[7] Basically, for normal walking balance, shock absorption and energy consumption. Cerebral palsy patients mainly affect these factors due to tonal abnormality, altered muscle performance and postural abnormality.[8] Because of all these factors present in cerebral palsy patients, there is increase in energy expenditure in these children. So, one of the outcome measures used in Cerebral Palsy is to evaluate the improvement in energy consumption of ambulation. The methods of evaluating energy consumption in Cerebral palsy include measurement of oxygen consumption and calculation of the Physiological Cost Index. The Physiological Cost Index was introduced by MacGregor and it is calculated by estimating the speed of walking and the increase in heart rate after the child has walked a specified distance at a self-selected pace.The physiological cost index assumes a linear relationship between oxygen consumption and heart rate at submaximal levels and therefore uses heart rate as an indicator of energy expenditure.[9]

Several studies have been conducted that compare the Physiological Cost Index between normal children and patients with Cerebral palsy. One of the distinct factors affecting Physiological Cost Index with Cerebral palsy is the tonal abnormality in lower limb. However, it is unclear if the extent of tonal abnormality is related to gait parameters and in turn in Physiological Cost Index, within a group of subjects with Physiological Cost Index. Hence this pilot study is conducted to investigate if the extent of tonal abnormality in hamstring and TA muscles measured with Modified Tardieu Scale affects the spatial parameters of gait and Physiological Cost Index.

2. Methodology

This is a pilot study which is a part of longitudinal research project spanning over two years the evaluation was carried out on 5 spastic diplegic children, out of which 3 were girls and 2 were boys. All subjects were aged between 4 to 15 years. The following inclusion and exclusion criteria were used for selection of children with Cerebral palsy: children with Cerebral palsy should be a clinical diagnosis with spastic diplegic Cerebral palsy, Spastic diplegia patients who were able to walk without support and were therefore classified as Gross Motor Function Classification (GMFC) System level I or II, the patients between age group of 4 to 15 years and patients who were able to follow the commands were included in the study. The children who had undergone orthopaedic intervention that is selective dorsal rhizotomy then patient with any medical condition such as cardiovascular disease, the children whose Gross motor function classification score is more than 3 and the children who received Botulinum treatment from last 6 months all were excluded from the study.All subjects and their parents received full information about the study and they were provided the written informed consent prior to their participation in the study.

The gait analysis on all the subjects was done by manual method that is by instructing the participant to walk barefoot with their normal speed on a 5-mt stretch of plain white paper with inked foot within a fixed time and it was recorded using a stopwatch. Prior to data collection, all participants had an opportunity to practice walking, as first few steps were discarded.The gait parameters analysed were step length, stride length, cadence and gait speed which was calculated. Step length was calculated by measuring the distance between heel strike of one extremity to heel strike of opposite extremity. Stride length was calculated by measuring the distance between heel strike of one extremity to heel strike of same extremity. Cadence was calculated by counting the number of steps taken by the participant. Gait speed was calculated by recording the time using a stopwatch which was taken by a participant to complete 5mt distance.

Then spasticity of hamstrings andTA muscles of all the subjects was measured using Modified Tardieu Scale. It is used to measure spasticity that takes into account resistance to passive movement at both slow and fast speed. The angle of muscle reaction was measured in which R1 and R2 was calculated as R1 is defined as angle in which a catch is found during quick stretch (V3) and R2 is defined as the angle of full range of motion which is taken at very slow speed (V1). The difference in R1 & R2 angle represents the dynamic tone component of a muscle. The Tardieu Scale differentiates spasticity from contracture, and having had good reliability and validity.

Physiological cost index was measured to determine the efficiency of the gait in children with cerebral palsy which is used as a simple, indirect measure of oxygen cost during exercise. For assessing Physiological cost index, firstly the participants were asked to sit comfortably on a chair for 5 minutes till that time resting heart rate was recorded using pulse oximeter, then the participants were asked to walk for 10-meter distance by that time walking pulse rate and speed was recorded using stop watch and using these data, the Physiological Cost Index will be calculated.

Formula for calculation PCI is PCI (beats/min) = Walking heart rate – Resting heart rate / walking speed (m/min)

3. Result

The baseline demographic characteristics of the subjects enrolled in the study were as follows. As there were 3 girls and 2 boys and the mean age of the subjects with CP are 9±4. The following table describes the mean score of hamstrings and TA muscle spasticity which was measured by Modified Tardieu scale, gait parameters including step length, stride length & walking speed and Physiological cost index of all the 5 children with cerebral palsy.

Table: Showing Spasticity, Gait parameters & PCI

S. No	Mean Score of Spasticity		Stride Length (cm)	Step Length (cm)	PCI	Walking Speed (mt/sec)
	Hamstring	TA				
1	6.5	9.0	27.8	23.9	0.23	0.33
2	10.0	6.5	43.6	19.0	0.12	0.25
3	6.0	6.0	22.1	14.3	0.14	0.20
4	9.0	3.0	56.15	26.83	0.18	0.27
5	45.0	10.0	44.4	20.84	0.11	0.18

4. Discussion

The aim of this pilot study was to describe if the tonal abnormality in hamstring and TAmuscles affect the spatial parameters of gait and Physiological Cost Index in the patients with Cerebral palsy. Our findings showed significantly lower spatiotemporal gait parameters, including walking speed, step length and stride length in children with spastic diplegic Cerebral palsy than in normal developmental children in the presence of mild spasticity in hamstrings and TA muscles. It usually occurs because of spasticity, motor weakness and poor voluntary motor control, children with Cerebral palsy use a wider step width than normal developmental children.[6]

According to the previous studies, when comparison was done between normal developmental children and cerebral palsy children it was observed that walking speed was considerably reduced in children with cerebral palsy. One of the factors responsible can be due to increase tone in one of the group of muscles which does not allow relaxation of opposite group and hence required extra effort to walk.[10]

Another factor depends, because of the abnormal muscle tension of children with cerebral palsy, in this children their coordination and balance are poor and there are more unusual fluctuations during the process of walking. This type walking results in the backward motion of the upper body which manages continuous flexion of the hip joint, and mainly in children with cerebral palsy the trunk angle changes from the both sides when children walk.[14]-[16]

Our findings are consistent with those of previous studies reporting that there is deterioration of gait function and altered gait pattern in children with cerebral palsy and it was observed that one of the children with cerebral palsy had increase in the tonal abnormality as compare to other children which resulted in decrease in physiological cost index and walking speed than others which in turn results in increase in energy consumption in the child with large degree of spasticity.

One of the studies done by Pauk et al, in which they determine the differences and the comparison in spatial-temporal gait parameters and magnitude of plantar pressure distribution between children with spastic diplegia Cerebral palsy and typical children. The result in theirstudy showed that there were significantly different gait parameters in children with spastic diplegic cerebral palsy than in typical children, especially of lower spatial-temporal gait parameters such as velocity, stride length, and step length. The mechanism suggested in the study was because of motor weakness and poor voluntary motor control, children with cerebral palsy use a wider step width than typical children, suggesting that children with cerebral palsy may choose a wider base of support in order to stabilize the centre of mass.[5]

One of the study done by Bhise et al, in this study the result showed that walking with orthosis in spastic diplegic cerebral palsy children showed higher costs of energy and slower walking speed compared to normal children, and the Physiological cost index of walking with orthosis in children with spastic diplegic cerebral palsy is less as compared to without orthosis that is gait is more energy efficient with orthosis. The mechanism related to ankle foot orthosis is that it is used as a pendular gait pattern which allows better energy recovery and leads to increase in energy variation, which meant that the work per meter on the Centre of mass is fixed. Spastic diplegic cerebral palsy mainly requires elevated energy consumption during walking as compared to normal individuals, mainly this occurs when there is knee flexion contracture which leads to increase requirements of gait.[11]

Another study done by Furukawa et al, the result in this study showed that the deterioration of walking duration in children with cerebral palsy might be caused by walking coordination and stability to joint deformity, spasm or muscle weakness.[12]

In this pilot study it was seen that tonal abnormality in lower limb may lower the gait parameters as well as physiological cost index in children with Cerebral palsy as compare to normal children. In the current pilot study combined effect of Hamstrings and TA has been observed. Spasticity in Hamstrings and TA muscles may have a different impact on gait parameters and hence further study can be conducted investigating the effect of individual muscle spasticity on gait parameters.

5. Conclusion

The study concluded that tonal abnormality in hamstring and TAmuscle may affect gait parameters as well as physiological cost index in children with Cerebral palsy.

6. Acknowledgments

I would like to thank my esteemed guide Dr.Suvarna Ganvir, Professor and HOD, Department of Neurophysiotherapy, DVVPF's COPT, Ahmednagar, has been a constant source of support throughout the study. I would also like to thank my colleagues and my seniors for guiding me as and when required during the study.

Funding – None

Conflict of Interest – None Reported

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