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COMPARISON OF KNEE JOINT PROPRIOCEPTION IN SPASTIC DIPLEGIC AND TYPICALLY DEVELOPING CHILDREN OF AGE 5-12 YEARS; A CROSS-SECTIONAL STUDY

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ABSTRACT

Objective: To compare quantitatively the error made in knee joint proprioception by typically developing and spastic diplegic children of age 5-12 years. **Design:** Cross sectional.
Participants: A total of 100 subjects were recruited, out of which, 80 (40 males, 40 females) were typically developing children (mean ± standard deviation of age was 8.88± 2.29 years) and 20(13 males, 7 females) were children with spastic diplegia (mean ± standard deviation of age was 9.54± 2.44 years). **Methods**: Passive reproduction of joint position of knee was checked by using a universal goniometer. Relative error was measured in degrees.
Results: Mean ± standard deviation of relative error in knee joint proprioception was 12.91±5.63 degrees for children with spastic diplegia and 1.80±2.15 degrees for typically developing children respectively. Comparison of the relative error between spastic diplegic children and typically developing children using the Mann-Whitney U test was highly significant with p value < 0.001 **Conclusions:** There was significant error in proprioception of knee joint in children with spastic diplegia as compared to typically developing children.

Key words: Spastic Diplegia, Cerebral Palsy, Proprioception, Knee Joint.

INTRODUCTION

Sensory integrity is the ability to organize and use sensory information. Sensory testing examines sensory integrity by determining the individual's ability to interpret and discriminate amongst incoming sensory information.[1]
According to Sherrington sensations are of three types: exteroceptive, proprioceptive and interoceptive. Pain, light touch and temperature are the exteroceptive sensations derived from sources outside the body. Interoceptive sensations are those arising from internal organs of the body. Sense of position, passive movements, vibrations and deep pain are the proprioceptive sensations derived from the body itself.[2] Out of these, proprioception plays an important role in the maintenance of joint stability and regulation of joint motion.[3]
Proprioception can be defined as the perception or awareness of change in muscle length, muscle tension in addition to perception of joint position and motion.[4] The main proprioceptors are muscle

spindle, Golgi tendon organs and joint receptors, all these receptors contribute to over all proprioceptive functions.[5] Of all the sensory modalities proprioception is perhaps the one most closely linked to locomotor activity. For motor functions to precede normally the nervous system must be continually appraised of the position of the body and the limbs.[6] The functions of proprioception are to increase body awareness and to contribute to motor control and motor planning.[7] Maturation of the proprioceptive function occurs by approximately 3 to 4 years of age.[8]

Injury, surgery, arthritis, cerebral palsy and other kinds of brain damage, and poorly modulated muscle tone can result in diminished proprioceptive perception and awareness.[9] Children with spastic cerebral palsy have deficits in proprioception, stereognosis, and 2-point discrimination.[10] In hemiplegic cerebral palsy proprioception is one of the chief modalities affected bilaterally.[11]

Proprioception can be tested in different ways that is qualitatively and quantitatively. Qualitative tests include ability to detect passive movement and recognition of direction of movement.[12] Quantitative assessment can be done by passive or active reproduction of joint position using equipments like isokinetic dynamometer, goniometer.[13] Qualitative proprioceptive deficits have been investigated in children with cerebral palsy (CP) and specifically in children with spastic diplegia.[10] A review of the literature reveals a large array of data on quantitative proprioceptive examination in adults.[14] Similar studies need to be done on spastic diplegic children.

There are studies on qualitative proprioceptive deficit in children with CP and specifically in children with spastic diplegia. However, studies on quantitative evaluation of proprioception could not be retrieved.

METHODOLOGY

A total of 100 subjects were recruited, out of which, 80 were typically developing children and 20 were children with spastic diplegia. Typically developing children with a mean age of 8.88 ± 2.29 years were taken from schools by random sampling. Inclusion criteria were typically developing children between 5-12 years of age. Children with any musculoskeletal, neurological, cardiopulmonary disorders and medical issues affecting proprioception were excluded. Children with spastic diplegia with a mean age of 9.54 ± 2.44 years were taken from tertiary care hospital and special schools by convenient sampling. Inclusion criteria were children with spastic diplegia between 5-12 years of age, knee extension at least 90^0 of flexion to 10^0 flexion on the right side of the lower limb, Modified Child Mini Mental State Examination (MCMMSE) [15] scores of >24 for 3-5 years,>28 for 6-8years,>30 for 9-11 years and > 35 for 12-14 and Gross Motor Function Classification System Expanded and Revised (GMFCS-E&R) [16,17] level of function II & III.

Children with spastic diplegia with fixed deformities of lower limb, with lower limb surgeries at hip and knee, with acute orthopedic problems of knee, hip and back, who are un co-operative and who were under any medication which would affect muscle tone such as botulinum toxin, phenol, baclofen etc were excluded.

The tester was a qualified physical therapist. Equipments used were Universal Goniometer, velcro straps, ruler, non toxic water soluble marker, chair, black ribbon. Approval was taken from institutional ethical committee. Block education officer was visited. Permission for conducting the

study in schools was obtained. Approval was also taken from Principals of schools and special schools. In brief the procedure was explained to the children and written consent was taken from parents of children who fulfilled the inclusion criteria.

Modified Ashworth Scale (MAS) [18, 19] was used to measure the spasticity of knee flexors in side lying position. Each child was made to sit on a chair or a bench without arm support and arms hanging by the side, with trunk-hip at 90 degrees, hip-knee flexion at 90 degrees.1-2 inch space was kept between popliteal fossa and chair. Greater trochanter, lateral femoral epicondyle and lateral malleolus were marked with water soluble marker pen. A line was drawn from greater trochanter to lateral epicondyle of femur and another from lateral epicondyle to the lateral malleolus. Goniometer was placed with fulcrum on lateral epicondyle, fixed arm along greater trochanter and movable arm along lateral malleolus. Both arms of the goniometer were secured with four Velcro straps.

Right hand of the tester was placed on lower end of leg of the subject. The tester placed the knee joint of the subject at 45^0 towards extension. Subject was clearly instructed to note this position with eyes open. Then subject was asked to note the same position when blind folded and remember it. The tester then moved knee joint to starting position and extended the knee. The limb was moved slowly towards extension.

Subject was clearly instructed that he/she had to say "STOP" as soon as the same position he/she had previously noted and supposed to remember had reached. When the subject said stop; corresponding angle was noted with the goniometer. A practice session of two trials was given to the subject. This was followed by taking three readings of the right knee of each subject. Relative error was noted in degrees. Mean was taken of the three values. At the end of the procedure the markings made on the subjects were cleaned. Intra-rater reliability was also calculated by using these measurements.

Statistical Analysis

Relative error in knee proprioception sense of typically developing children and children with spastic diplegia was calculated. Mann Whitney U test was used to compare data obtained in typically developing children and children with spastic diplegia. Intra-rater reliability of goniometer was calculated and Alpha value was obtained. SPSS version 13.0 was used. p value less than 0.05 was taken as significant.

RESULTS

A total of 100 subjects were taken to measure relative error made in knee joint proprioception, out of which 20 were children with spastic diplegia and 80 were typically developing children.

All children with spastic diplegia had full range of knee flexion but knee extension range was not complete for all; 70% of children had complete extension whereas 30% had 10 degrees extension lag. MAS was used to measure spasticity. 4 spastic diplegic children had MAS score of I and 16 had score of II for knee flexors. GMFCS-E&R was used to determine child's present abilities and limitations in gross motor function. Out of 20 children with spastic diplegia, 4 children were at GMFCS-E&R level III and 16 were at GMFCS-E&R level II. Mean Modified child MMSE score was 32.90. Characteristics of children with spastic diplegia were specified in Table-1.

Three readings of knee joint as indicated by children were taken with a universal goniometer. Alpha values were calculated to know the intra-rater reliability of universal goniometer used in the study. Alpha value was found to be 0.96 and 0.79 respectively for both children with spastic diplegia and typically developing children indicating the strong reliability of the instrument.

Mean and standard deviation of measured knee angle was 45.02±14.40 for children with spastic diplegia and 44.60±2.79 for typically developing children. Mean relative error in knee joint proprioception was 12.91 for spastic diplegics and 1.80 for typically developing children (Graph-1). Comparison of the relative error between spastic diplegic children and typically developing children using the Mann-Whitney U test was highly significant with p value < 0.001 (Table-2).

Comparison of relative error made by children with spastic diplegia MAS score I and II was done and it was found that children with MAS score II had greater error as compared to those with MAS score I which was statistically significant (Table-3).

DISCUSSION

Proprioception refers to sensation of movement that includes speed, rate, sequencing, timing, force and joint position .The role of proprioception is to provide motor system with a clear unambiguous map of the external environment and of the body.

In this study we compared the error made by spastic diplegic children and typically developing children in knee joint proprioception. A total of 100 children were recruited, of which 80 were typically developing and 20 were children with spastic diplegia. The results show that error made by spastic diplegic children is highly significant as compared to typically developing children.

Results of this study co-relate with the previous study by Opila et.al where kinesthetic recall of shoulder was checked in normal, spastic cerebral palsy and athetoid cerebral palsy children. In that study error made by spastic CP children was significantly higher ($p<0.05$) as compared to normals and athetoid CP .[20] In this study we examined the passive reproduction of joint position of knee and found that error made by children with spastic diplegia is statistically significant as compared to typically developing children (p value <0.001).

The knee joint proprioception may be affected in children with spastic diplegia due to increase in muscle tone, abnormal firing of muscles, abnormal weight bearing and postures. Experience of movement and feedback that a child receives continually influences the development of motor control and proprioception. Since spastic children experience diminished movement and consequently reduced kinesthetic input, they may make more errors on a kinesthetic task. These expectations are consistent with re-afference theory, which contends that sensory feedback generated by a movement (re-afference) is compared to the efferent signal generated. If the re-afference is identical to the efferent signal, then this match is stored for future use called the 'comparator storage'. Since normal children experience many movements, their 'comparator storage' is finely tuned in efferent-re-afferent trace combinations. Children with spastic cerebral palsy move infrequently and therefore have the least amount of motor memories available to them.[20] Delayed myelination of fiber tracts also contribute. All the above factors are the reasons ascribed for significant

proprioceptive error found in proprioception of knee in children with spastic diplegia.

Error found in children with spastic diplegia and MAS score II was higher and statistically significant as compared to error made by children with MAS score I. This maybe attributed to greater spasticity in MAS scores II in children with spastic diplegia. Increased tone may cause abnormal posturing and weight bearing which might be the cause of increased error in proprioception. Excessively high tone may be associated with poorly modulated proprioceptive sense.[9]

GMFCS classification score indicated clinically a greater proprioceptive error at level II then at level III but this was not statistically significant .The ability to stand or ambulate could not be co-related with the proprioception error as number of diplegics who were unable to ambulate were only 2 as compared to 18 ambulatory children.

Limitations of this study include small sample size of children with spastic diplegia as compared to typically developing children. Goniometer used in this study may not be as accurate as sophisticated instruments like isokinetic dynamometer, electro-goniometer.

Future study maybe conducted on the proprioceptive error in children with spastic diplegia, with a larger sample size. Similar research can also be done using more accurate instruments like electro-goniometer and isokinetic dynamometer. Further studies are also warranted to check proprioception at other joints in spastic diplegics.

CONCLUSIONS

There was significant error in proprioception of knee joint in children with spastic diplegia (12.91 ± 5.63 degrees) as compared to typically developing children (1.80 ± 2.15 degrees).

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Table 1: Description of spastic diplegic children

Total Spastic Diplegia Children	Full Range Knee Flexion	Knee Extension		MAS Grades for Knee Flexors		GMFCS Levels		Mean MMSE Score
		Full range	10° Lag	I	II	II	III	
20	20	14	6	4	16	4	16	32.90

Table 2: Comparison of relative error between children with spastic diplegia and typically developing children

Group	N	Mean±SD	Mann Whitney U test	p value
Children with spastic diplegia	20	12.91±5.63	6.87	<0.001*
Typically developing children	80	1.80±2.15		

Table 3: Comparison of relative error and MAS score for knee flexors in children with spastic diplegia

MAS Grades for Knee Flexors	N	Mean±SD	Mann-Whitney U Test	p value
I	4	7.50±2.89	-2.33	.020
II	16	14.27±5.37		
Total	20	12.92±5.64		

Graph-1: Comparison of relative error between children with spastic diplegia and typically developing children