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Original Research Article

Effect of Lumbar Position Sense on Lumbar Muscle Strength, Static versus Dynamic Balance and Functional Status in Children with Spastic Diplegic Cerebral Palsy: A Cross-Sectional Study

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ABSTRACT

BACKGROUND: Cerebral palsy (C.P.) is the most common motor disability of childhood in which spastic diplegia have primarily lower extremity involvement with weak trunk musculature. While deficits of trunk muscle strength have been identified, it is unclear whether they have adequate proprioception to ensure stable balance for functional tasks.
OBJECTIVE: To assess lumbar position sense and its effect on lumbar muscle strength, static versus dynamic balance and functional status in children with spastic diplegic cerebral palsy.
METHODOLOGY: 44 children aged 5 to 15 years with spastic diplegic C.P meeting inclusion criteria were recruited from tertiary care centres in Surat city. Lumbar repositioning error was assessed by bubble inclinometer in degrees. Outcome measures included lumbar muscle strength (assessed by manual muscle test), static balance (using static components of pediatric balance scale), dynamic balance (using dynamic components of pediatric balance scale & dynamic gait index) and functional status (measured by WeeFIM).
RESULT: The correlation between these variables was tested using Spearman's correlation coefficient. A p value of <0.05 was considered statistically significant. Significant negative correlation was found between lumbar repositioning error and lumbar muscle strength, static, dynamic balance and functional status. Also, significant positive correlation was found between lumbar repositioning error and GMFCS.
CONCLUSION: Children with spastic diplegic C.P. with better lumbar position sense showed greater muscle strength and balance. Although both static and dynamic balance were affected with increased repositioning errors, static was more affected so interventions focusing more on static balance and proprioceptive training should be kept in mind.

Keywords: Position Sense, Repositioning error, muscle strength, static balance, dynamic balance, functional status

INTRODUCTION

Cerebral palsy (CP) refers to a group of permanent disorders in the development of movement and posture causing activity limitation that are attributed to non-progressive disturbances that occur in the developing fetal or infant brain. These motor disorders of CP are often accompanied by disturbances of sensation, cognition, communication, perception, behavior, and epilepsy.[1] In India, the prevalence of cerebral palsy was reported to be 2.95 per 1000 live births.[2] Among the various types of C.P, spastic diplegia accounts for about 44% of the total incidence of CP characterized by greater motor impairment in the lower extremities compared to the upper extremities. [3]

Sensory deficits in children with CP, including proprioceptive dysfunction, can affect postural control. Proprioception consists of 3 main sensations: the sensations of position and movement of joints; the sensations of force, effort and heaviness associated with muscular contractions and the sensations of the perceived timing of muscular contractions.[4] Proprioceptive inputs are derived from afferent information received from joint, muscle and skin receptors. These receptors have varying roles depending on the range at a given joint, for instance, previous studies have found that joint receptors are activated near the end of the joint range, while muscle spindles provide afferent inputs throughout the physiologic ranges. [55] Joint position sense, a component of proprioception, enhances body awareness and contributes to motor planning and control.[6]

Trunk position sense plays a crucial role in spinal stability and mobility and is impaired in children with spastic CP.[7] A study evaluated trunk position sense in children with CP and found that trunk repositioning errors were significantly higher compared to the normal error of 2.6°.[7] Lumbar position sense is assessed by measuring Lumbar repositioning error (LRE).[5]

Children with spastic cerebral palsy have poor trunk control due to weak trunk muscle strength, altered neural control and inadequate position sense.[7] Core muscle strength in children with diplegic CP is related to gross motor functions, with the diplegic group showing the most significant deficits in trunk flexor and extensor muscle strength compared to healthy peers.[8] Coactivation of both lumbar flexors and extensors is unavoidable during trunk movement, as they function together to maintain balance.[9] However, no study to date has explored the relationship between lumbar position sense and lumbar muscle strength.

Functional Balance is impaired by poor postural control mechanism and children with CP have poor balance. Weak trunk muscles are a primary factor in reduced functional abilities directly impacting daily activities by causing inadequate static and dynamic balance.[3] Static standing balance is traditionally assessed either by the duration of maintaining the balance and/or by the postural stability and is important for upright and independent walking. Dynamic balance refers to maintaining equilibrium between the body and its environment while in motion and is essential for all locomotor activities.[10] Previous studies have found that trunk control and balance are impaired to varying degree in children with cerebral palsy[11] ,but no studies have investigated the impact of lumbar position sense on static versus dynamic balance, which would clarify which is more significantly affected. Additionally, it remains unclear whether lumbar repositioning error has a minor or major impact on dynamic balance which is essential for functional independence.

Daily routine activities are essential for children with cerebral palsy, who often face significant challenges in completing them. The Functional Independence Measure of Children (WeeFIM), derived from the Functional Independence Measure (FIM), is widely used methods for the pediatric functional evaluation of daily living activities. Recent studies have confirmed the reliability and validity of the WeeFIM for both children with disability and healthy children.[12] Gross Motor Function Classification System(GMFCS) assesses varying level of severity of movement disability[13] and those children with low level of GMFCS had impaired trunk control suggesting relationship with functionality.[14]

Therefore, the purpose of this study is to assess lumbar position sense and determine its effect on lumbar muscle strength, static versus dynamic balance and functional status in children with spastic diplegic cerebral palsy.

METHODOLOGY

Study Design: Cross Sectional study
Study Population: Children with spastic diplegic cerebral palsy
Study Setting: Various tertiary care centres in Surat city
Study Duration: Six months after ethical approval
Sample Size: 44
Sampling Technique: Purposive Sampling

Inclusion Criteria:

- Age:5-15 years
- Sex: Male and Female Subjects
- Children who were diagnosed by Neuro – Physician as Spastic Diplegic Cerebral Palsy.
- Children who had spasticity according to Modified Ashworth Scale ≤ 2.
- Children with GMFCS level I, II.
- Children who were able to understand and follow verbal commands.
- Children whose parents had willingly given informed accent for participation.

Exclusion Criteria:

- Visual and Hearing problem
- History of neurological, medical conditions other than C.P such as traumatic brain injury, acute pneumonia, cerebellar or vestibular disorders, epilepsy.
- Mental retardation interfering in understanding and performing the task.
- Children who were on medication such as anti spastic drugs or have been administered neural blockers like botulinum toxin and phenol in last six months interfering with performance
- Musculoskeletal disorders or surgery pertaining to it in last 6 months.

PROCEDURE:

Lumbar repositioning error, as an indirect measure of position sense, was assessed using a bubble inclinometer in standing position.[5][7] LRE represents the difference between a target lumbar position and the position that a subject assumes when attempting to reproduce that initial position.[5]

-Each participant stood on a custom-made wooden frame with feet in a neutral position, shoulder width apart, knees extended (with straps), hips in neutral position, and pelvis strapped below the anterior superior iliac spine to minimize proprioceptive feedback from the lower extremity and pelvis

- The testing procedure was explained to each participant, followed by two practice trials, where each participant was passively moved to the target position of 30° trunk flexion and instructed to hold and memorize this position for 10 seconds with eyes open. After the practice trials, the participant returned to neutral position and were asked to replicate the target position as accurately as possible with closed eyes. The perceived target position was measured using a bubble inclinometer with the reference point at the L1 lumbar spinous process.

-Absolute repositioning error in degrees was measured as the absolute error (AE) between the target position and the actual measured angles irrespective of error direction.

-No verbal or visual feedback or clues were provided to the participants during the performance.

Given the muscle strength impairments associated with cerebral palsy (CP), a 30° angle was chosen to test lumbar position sense to avoid overloading the muscles, which could negatively affect the test results.[7]

Figure 1: Assessment of Lumbar Position Sense

Outcome measures

1. Lumbar Muscle Strength by Manual Muscle Test (MMT) of lumbar flexors and extensors [15]
2. Static Balance by Static components of Pediatric Balance Scale (PBS-static, 6 items). [16]
3. Dynamic Balance by
   - Dynamic components of Pediatric Balance Scale. (PBS-dynamic, 8 items) [16]
   - Dynamic Gait Index. (DGI) [17]
4. Functional Status by Functional Independence Measure of Children. (WeeFIM) [12]

STATISTICAL ANALYSIS

IBM SPSS Statistics version 29 was used for data analysis. The correlation of lumbar position sense, lumbar muscle strength, static versus dynamic balance and functional status was done using Spearman's correlation coefficient as the data was not normally distributed, which was revealed by using visual (histogram) and analytical (Shapiro-Wilk) test. A *p* value of <0.05 was considered statistically significant. Spearman's coefficient ranges from –1 to +1. Correlation coefficient (r value) between 0.00 and 0.10 indicates a negligible correlation, 0.10 to 0.39 as weak correlation, 0.40 to 0.69 as moderate correlation, 0.70 to 0.89 as strong correlation, and 0.90 to 1.00 as very strong correlation.[7]

RESULTS

This study included 44 children with spastic diplegic cerebral palsy and their demographic characteristics are shown in Table1. The average age of the children was 8.29 ± 3.66 years.

Table 1: Demographic data of participants of the study

		n	%
Age Group (5-15) years	**5-10**	**32**	**73**
	11-15	**12**	**27**
Gender	**Male**	**31**	**70**
	Female	**13**	**30**
GMFCS	**I**	**18**	**41**
	II	**26**	**59**

Results were expressed as summary measures (median and interquartile range) depicted in Table 2.

Table 2: Descriptive analysis of participants

	Min	Max	Median	Interquartile Range
Lumbar Repositioning Error (°)	3	10	5	3
Lumbar Flexor Strength /5	2	4	2	1
Lumbar Extensor Strength /5	2	4	2	0
Static Balance /24	10	22	15	3.25
Dynamic Balance (PBS) /32	22	30	26	2
Dynamic Balance (DGI) /24	14	23	19	2
Dynamic Balance (Total) /56	36	52	44.5	3
Functional Status (WeeFIM-Motor) /91	60	91	74	13.25
Functional Status (WeeFIM-Cognitive) /35	18	35	32.5	5
Functional Status (WeeFIM-Total) /126	85	126	106	12.5

Relationship between lumbar position sense and lumbar muscle strength

Negative correlation between lumbar repositioning error and lumbar flexor and extensor strength in children with spastic diplegic cerebral palsy implies that lumbar repositioning error has moderate effect on lumbar muscle strength

Relationship between lumbar position sense and static, dynamic balance

Strong negative correlation between lumbar repositioning error and static balance in children with spastic diplegic cerebral palsy interprets that lumbar repositioning error has significant effect on static balance and weak negative correlation between lumbar repositioning error and dynamic balance in children with spastic diplegic cerebral palsy interprets that lumbar repositioning error does not play major role on dynamic balance.

Relationship between lumbar position sense and functional status

Strong negative correlation between lumbar repositioning error and WeeFIM-total score in children with spastic diplegic cerebral palsy shows that lumbar repositioning error plays a significant role on functional status

Table 3: Correlation between variables

VARIABLES		Spearman's rho	p-value
Lumbar Repositioning Error	Lumbar Flexor Strength	-0.421**	0.004
	Lumbar Extensor Strength	-0.360*	0.016
	Static Balance	-0.791**	<0.001
	Dynamic Balance (PBS)	-0.339*	0.024
	Dynamic Balance (DGI)	0.315*	0.037
	Dynamic Balance (Total)	-0.380*	0.011
	WeeFIM (Motor)	-0.756**	<0.001
	WeeFIM (Cognitive)	-0.454**	0.002
	WeeFIM (Total)	-0.752**	<0.001

Also, strong positive correlation between lumbar position sense and GMFCS in children with spastic diplegic cerebral palsy (r= 0.757, p <0.001) depicts that GMFCS has significant effect on lumbar position sense.

DISCUSSION

The present study is aimed at determining effect of lumbar position sense on lumbar muscle strength, static versus dynamic balance and functional status in spastic diplegic cerebral palsy children.

We evaluated lumbar position sense in these children using a bubble inclinometer, revealing a minimum lumbar repositioning error of 3° and maximum error of 10° which was found to be higher than previous study on cerebral palsy by Monica et al who showed minimum and maximum trunk repositioning error of 1° and 8° respectively when evaluated with the help of digital goniometer.[7]

The current study found a significant negative correlation between lumbar position sense and lumbar muscle strength indicating lesser the position sense error, more is the strength. Contradictory to this, the study by Goldberg et al found no significant correlation between trunk repositioning error and trunk extensor strength in balance impaired older adults.[18] The discrepancy between these results may be due to the change in population.

The results of our study could be due to the increased myographic activity of paraspinal trunk extensor muscles during forward bending from a neutral standing position. This increased activity suggests that greater activation of these muscles is important for trunk flexion control. Accurate proprioception is possible due to balanced strength between reciprocal muscles. Several mechanisms could account for the relationship between muscle strength and proprioception.[19] Firstly weaker muscles may have fewer proprioceptors, leading to impaired proprioceptive input. Secondly, there may be a reduced muscle spindle sensitivity. Thirdly, fatigue could be a contributing factor.

Strong negative correlation between lumbar repositioning error and static balance scores (ρ= -0.791, p = <0.001) and weak negative correlation between lumbar repositioning error and total dynamic balance scores (ρ= -0.380, p = 0.011) suggests that lumbar position sense does not make larger contribution to dynamic balance but it plays major role in static balance. The reason to this might be attributable to the fact that in static balance, the ability of children to maintain COG over BOS when standing still is measured and during such task body primarily depends on proprioceptive system for maintaining balance, hence children with better lumbar position sense performed better in static balance.

Dynamic balance involves movement that require feed forward control where anticipatory postural adjustments are made to maintain stability. Individuals with CP can generate APAs but the APAs were smaller in magnitude when compared to healthy controls.[20] Moreover, in the presence of inaccurate or reduced information from the somatosensory system, this feed-forward control (APAs) relies more on the vestibular system which works greater in dynamic balance because of angular position of semicircular canal.[7] Additionally in our study, dynamic gait index was taken as all tasks demand some level of dynamic balance, one in particular was designed to stress vestibular and visually based balance by requiring the participant to walk with horizontal and vertical head turns.[21]

Similarly, strong negative correlation between lumbar repositioning error and functional status is in agreement with existing literature that individuals with impaired trunk position sense can perform motor tasks but the quality of the movement is compromised and the goal directed actions depict lack of precision and postural responses, causing impaired balance.[22] Also, this study shows moderate negative correlation between lumbar repositioning error and cognitive component of WeeFIM as child's cognitive ability and motivation influence his/her ability to do functional task

In our study we assessed lumbar position sense as measured by lumbar spine repositioning in standing position rather than sitting and four point kneeling because in previous study by Richard Preuss et al, it was found that test position significantly affects lumbar position sense acuity, with larger repositioning errors occurring in non-weight-bearing positions like sitting and four-point kneeling compared to standing.

Changes in spine orientation from weight-bearing to non-weight-bearing positions can affect proprioceptive feedback and spinal stresses. [23]

Thus, the findings of this present study represent the understanding of lumbar position sense impairments in spastic diplegic cerebral palsy children, it adds to the body of knowledge of lumbar muscle weakness, underlying factors for altered balance and functional limitations and aims to contribute new perspective to literature about proprioceptive training as an important intervention strategy to improve trunk stability as precursor to balance and functional activity.

CONCLUSION

The result of the study satisfied the Alternate Hypothesis. Children with Spastic Diplegic C.P with better Lumbar Position Sense scored greater in balance so intervention focusing on proprioceptive training on unstable surface and narrow base of support may further improve balance. Functional training is dependent on stability of trunk to carry out movements of upper and lower extremity and this study concluded that children with C.P with level 1 and 2 GMFCS had poor core stability represented by weakness of frontal and dorsal lumbar muscles so ambulant diplegic patients still needs core stability training with more concentration on lumbar muscles as well as extremities.

Limitations

Although findings were significant, but few limitations exist, the study consisted of only patients with spastic diplegic cerebral palsy, purposive sampling was used, though this study provides unique understanding of lumbar position sense, lumbar muscle strength and balance, the children included were from GMFCS level 1 and 2, so findings can't be generalized to all GMFCS levels

Recommendations

Future studies encompassing the effect of lower limb proprioception on static versus dynamic balance may contribute to a better understanding of the functional relationship in children with C.P, study can also be done to know the effect of trunk repositioning error on lower extremity muscle strength.

Declaration by Authors

Ethical Approval: Approved by HREC of Government Physiotherapy College, Surat

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