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Relation between balance and pelvic alignment in diplegic cerebral palsy children

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***Abstract*---**Background: Diplegia is one of the most common types of CP in which lower limbs are affected more than upper limbs, Pelvic malalignment is common in growing patients with diplegic CP develops due to the combination of spasticity, muscle weakness, as well as incompetent muscle control, this can result in poor pelvic control and significantly limits the patient's ability to maintain balance. Aim of the Study: This study was conducted to study the relationship between balance and pelvic alignment in diplegic cerebral palsy children. Materials and Methods: Fifty children with diplegic cerebral palsy from both sexes (18 girls and 32 boys) grade I (33) and grade II (17) according to gross motor function classification system and 1 (23), 1+(15) and 2 (12) according to modified Ashowrth scale. Their ages ranged from 7-10 years, postural deviations were evaluated using the 3D measurement system Formetric while balance was assessed using Biodex balance system. Results: There was a statistically significant relation between overall stability index (OASI) and pelvic alignment (pelvic tilt- pelvic inclination). Conclusion: The obtained results suggested that there was significant correlation

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between balance and pelvic alignment in diplegic cerebral palsy children.

***Keywords*---**cerebral palsy, diplegia, balance, pelvic alignments.

Introduction

Cerebral palsy (CP) is the most common childhood-onset physical disability with varied impact on daily activities and participation [(1)]. It is anon progressive lesion that causes disorders of movement and posture caused by damage to the motor cortex. The consequences of chronic muscle imbalance and the resultant deformities cause increasing disability with age [(2)]. Balance control is the ability of an individual to recover from unexpected threat to balance, such as a slip or a trip [(3)]. Optimal posture implies balanced distribution of body mass around the center of gravity where the compression force is balanced by ligamentous tension and there is minimal energy expenditure from postural muscles [(4)]. Diplegia is weakness of all four limbs, but that the legs are weaker than the arms [(5)]. Children with diplegic CP encounter difficulties in sensory processing and integration which influence the achievement of mature postural control leading to balance impairments [(6)]. The deviation of pelvic alignment in the standing position is a common problem in children with diplegic CP [(7)]. Therefore, the purpose of this study was to study the relationship between balance, and pelvic alignment (tilt and inclination) in diplegic cerebral palsy children.

Patients and Methods

Fifty diplegic cerebral palsy children from both sexes aged from 7 to 10 years participated in this study. They were selected from the outpatient clinic of National Institute of Neuromotor System in the period from 1/10/2020 till 20/4/2021. This study was conducted on the Research Laboratories of Faculty of Physical Therapy, Cairo University.

Subjects were diagnosed as having diplegic cerebral palsy based on careful clinical assessment by a neuropediatrican. Approval from Ethical Committee of the Faculty of Physical Therapy, Cairo University No (**P.T.REC/012/003122**), In addition to written consent forms signed by children's parents before starting this study.

Study design: cross sectional correlational study

Inclusion criteria:

Children were selected according to the following:

- Age of children from 7 to 10 years.
- Level I and II motor function according to the Gross Motor Function Classification System (GMFC) [(8)].
- Grade 1 to 1+ spasticity according to Modified Ashworth scale [(9)].
- All children had to be able to understand instructions and cooperate during assessment.

- All children had to be able to stand up without support on the force plate bare feet, with full foot contact.

Exclusion criteria:

Children were excluded if they had:

- Lower limb muscle contractures that would limit their function in an upright position, such as contractures of the hamstrings, adductors, hip flexor or plantar flexor muscles.
- Previous history of Botox injection within last six months.
- Previous history of orthopedic surgery in lower limbs or back.
- Visual or auditory problems.
- Seizures.
- Intellectual disorders.
- Sensory or perceptual deficits.

Instrumentation

1-For subject selection:

- Gross Motor Function Classification System – extended and revised version (GMFCS-ER).
- Modified Ashworth scale.

2-For evaluation of balance

- Biodex balance system (BBS).

3-For evaluation of posture

- 3D measurement system formetric.

Evaluation procedures:
1-For evaluation of balance
Biobex Balance System:

Assessment of balance includes (overall stability index, Antroposterior (AP) stability index and Mediolateral (ML) stability index.
The following data was introduced to the software of the device:
• Weight, height, and age.
Level 8 of stability was selected for testing balance [10] which is the most stable level of stability and the tested parameters were (overall stability index, AP stability index and ML stability index)

Dynamic Balance test:
Steps:

- All children were given an explanatory session before the test to be aware of the steps of the evaluation procedures.
- Each child in both groups was asked to stand on the center of the platform bare feet.
- The screen was adjusted and the support rails were modified to the comfortable level of each child.
- The child was allowed to stand on the platform with both feet while catching the hand rails then was asked to shift his/her feet position till it was easy to keep his standing balanced over the unstable platform.

- Once centering was achieved, the child was asked to keep his/her feet position till recording the feet angles and heel coordinates from the platform and introduced into the BBS.
- The child was asked to focus on the visually feedback screen in front of him with his/her arms beside his/her body without grasping the rails.
- Each measurement was done for three trials then the average was calculated.

Outcomes of the Biodex Balance System:

- Stability Index: Represents the variance of platform displacement in degrees from level.
- Anterior/Posterior Stability Index: Represents the variance of platform displacement in degrees from level for motion in the sagittal plane.
- Medial/Lateral Stability Index: Represents the variance of platform displacement in degrees from level for motion in the frontal plane.
- A high number is indicative of poor neuromuscular control, which may increase the potential for orthopedic injury or falling.

3-For Evaluation of posture
3 D measurement Formetric instrument system:

- The procedures according to (Youesef et al., 2011) were explained to the children and their parents [11].
- Standing posture for the child was assessed.
- The software program was started.
- The child's back was completely bare, and positioned in front of the black background screen in a distance of two meters from the measurement system, with both upper extremities extended beside the body.
- Height adjustment of the optical column was done before exposure control in order to measure the correct image section.
- The column height was aligned to move the relevant parts of the child's back into the center of the control monitor.
- The child was asked for normal breathing, and then asked to stop breathing for seconds while image capture was released. The best moment for releasing image capture is the slightly breathed out state.
- Two main values were evaluated: pelvic tilt, and pelvic inclination.

Results

The collected data from this study represented the statistical analysis of balance measured by BBS and pelvic alignment measured by 3D measurement Formetric instrument system and data were obtained from all children.

Demographic and clinical characteristics of children

Fifty children with diplegic cerebral palsy participated in this study. The distribution of boys and girls was (30 boys and 20 girls) the mean ± SD age, weight and height of children were 8.99 ± 1.18 years, 30.2 ± 9.09 kg and 128.46 ±

7.78 cm respectively. GMFCS distribution was 33 cases for grade I with percentage of 66% and 17 cases grade II with percentage of 34%, Spasticity grades distribution was 23 cases for grade 1 with percentage of 46%,15 cases grade 1+ with percentage of 30%, and 12 cases grade 2 with percentage of 24.A participant characteristic is presented in table (1).

The mean value ± SD of pelvic tilt, pelvic inclination and of children with diplegic cerebral palsy were 8.69 ± 7.45 degrees and 17.16 ± 7.7 mm respectively while the mean value ± SD of OASI was 2.02 ± 0.54 (table 2).

The relations between OASI and postural deviations in children with diplegic cerebral palsy were moderate positive significant correlation with pelvic inclination (r = 0.362, p = 0.01), moderate positive significant correlation with pelvic tilt r = 0.429, p = 0.002 (table 3) and figure (1 and 2).

Table (1): Demographic and general characteristics of children

Diplegic children		
Sex distribution		
Girls	18	36%
Boys	32	64%
GMFCS distribution		
Grade I	33	66%
Grade II	17	34%
Spasticity grades distribution		
Grade I	23	46%
Grade I+	15	30%
Grade II	12	24%

Table 2. Descriptive statistics of pelvic alignment and balance of children with diplegic cerebral palsy:

Measurement	Mean ±SD	Minimum	Maximum
Pelvic tilt (mm)	8.69 ± 7.45	0.7	31.7
Pelvic inclination (degrees)	17.16 ± 7.7	1	28.6
OASI	3.05 ± 0.63	1.8	4.9

SD: Standard Deviation

Table 3. Relation between OASI, and pelvic alignment in children with diplegic cerebral palsy.

		Pelvic tilt	Pelvic inclination
OASI	**r value**	0.429	0.362
	p value	0.002	0.01

r value: Pearson correlation coefficient; p value: Probability value.

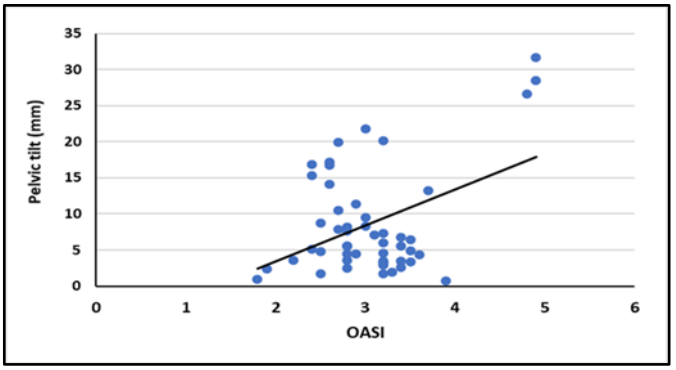

Figure (1). Correlation between OASI and pelvic tilt in children with diplegic cerebral palsy

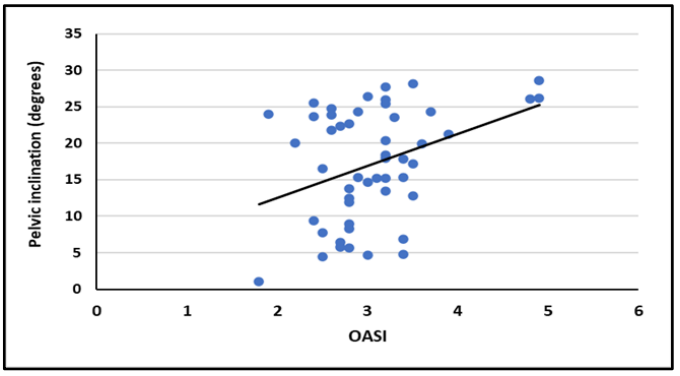

Figure (2). Correlation between OASI and pelvic inclination in children with diplegic cerebral palsy.

Discussion

The purpose of this study was to investigate the relation between balance and pelvic alignment (tilt and inclination) in diplegic cerebral palsy children. Cerebral palsy children show problems with positioning of the body in space, malalignments in posture while standing which result from primary and secondary impairments in CP [12–13]. Previous research by (14) has shown that the neuromuscular response characteristics that contribute to balance show specific constraints in children with CP while (Giannoni & Zerbino 2022) said that Cerebral palsy children shows asymmetrical postures for prolonged periods due to poor ability of a child to move spontaneously which leads to emergence and progression of postural deformity (15).

Asymmetric alignment between the pelvis and the lower limbs affects the stability of the lower limbs and the trunk, making balance difficult (16). Sustaining an incorrect posture for a long time triggers inappropriate tension in the adjacent muscles and joints. Consequently, flexibility decreases, and the patient experiences restricted movement and balance (17).

Posture and balance adjustment ability provide the basis for all motions. During ordinary life, many tasks require the adjustment of posture and balance, which

are maintained by the center of gravity within the base of support (BOS). When the BOS changes, the balance adapts to the new situation through the postural adjustment system [18]. When the neuromusculoskeletal system is damaged, stability maintenance, weight load adjustment, decline in the standing posture, which has a negative effect on functional recovery, resulting in functional and balance problems [19].

Pelvic tilt is one of the spastic diplegic children's major problems because pelvic attaches to the spine and the lower limbs transmitting vertical forces between them as a part of the kinetic chain. So, the pelvis transmits the biomechanical disturbance of the lower limb to the trunk [20].

Presence of trunk imbalance in spastic diplegic cerebral palsied children may be due to functional leg length discrepancy, poor alignment of the legs, pelvis and trunk, weakness of trunk muscles and poor postural reflexes as reported by [21]. Who said that functional leg length discrepancy occurs due to asymmetrical weakness of calf muscles, quadriceps and hip extensors, along with hamstring and adductor spasticity in lower limbs, asymmetrical hip abduction, and increased co-activation of abdominal and back muscles causing poor dissociation of the pelvis from the trunk which leads to pelvic tilt.

Conducting this study on children aged from 7 to 10 months comes in agreement with [22] who emphasized that literature advocates that maturation of gait complete by 7 years and [23] who said that gait is relatively normalized from the age of 7 years and stabilized by 10 years which reflects development of balance system, In addition to [24] who mentioned that Pelvic obliquity is likely to be detected early in childhood, and [25] who said that Hip problems in CP often appear at 2-3 years of age and becomes prominent by the age of 10 years, and the risk of deformity continues thereafter.

Mean values of balance (OASI) using Biodex balance system was 2.02 ± 0.54 (table 3). while mean values of pelvic tilt and inclination were 8.69 ± 7.45 mm and 17.16 ± 7.7 respectively. The relations between OASI and pelvic alignment were moderate positive significant correlation with pelvic inclination ($r = 0.362$, $p = 0.01$), moderate positive significant correlation with pelvic tilt ($r = 0.429$, $p = 0.002$). These results come in agreement with [26] who reported that in ambulators CP children pelvic obliquity may affect standing balance, limiting walking ability, and impair walking capacity.

Results also come in agreement with (Jeong and Yoon, 2006) who said that Pelvic malalignment triggers difficulty in maintaining balance and normal gait [27] and (Pai et al.,1994) who added that in normal gait, the joints and muscles of the pelvis and legs operate in coordination and When disharmony in this operation occurs, abnormal gait and balance appears [28].

It was reported that asymmetric posture resulted in shifts of the weight supported by the lower limb during the swing phase, the backward tilting of the pelvis shifts the body center to behind median line, making it difficult for the lower limb to move forward [29].

In standing, the normal side to side pelvic alignment is controlled by the activity of hip abductors along with trunk control, while researchers stated that the impaired recovery pattern of hip abductor and adductor in standing is responsible for side to side balance stability problems. He added that the muscles of the lower trunk and hip working onto pelvis seem to be vital for activation of hip abductor and trunk side flexor during side to side weight shifts. Such muscular coordination is required for dynamic pelvic stability, thus allowing better weight bearing symmetry and balance control [30].

Atypical pelvic alignment was correlated to trunk and balance dysfunction [31] this suggests that pelvic stability is well coordinated by trunk pelvic and pelvis hip dissociation. It is interesting to note that pelvis plays a role of the trunk in sitting whereas it is mainly a part of the lower extremity in standing. In sitting, the forward inclination of the trunk in sagittal direction was assisted by hip extensors, whereas the sideways movement of the body was controlled by leg muscles, beside trunk muscles. However, people with worse lower trunk control shall fix the pelvic backward and can translate the body weight forward by excessively flexing upper trunk. Furthermore, the weight bearing center of pressure values on feet as measured by force plates was less suggesting that asymmetrical weight bearing is always an issue during many of the functional tasks that challenge the balance [32].

Results of the study disagree with [33] who found no significant correlation between balance function and pelvic tilt, adding that pelvic inclination could not affect balance function. Research also found that there were no significant correlations between the pelvic inclinations and balance [34]. Meanwhile, this opinion was contradicted by [35] who found positive correlation between the pelvic malalignment, weight distribution index, and the 10-meter walk test, and these results mean that increased pelvic malalignment causes decreased balance ability.

Although research supports those significant correlations were observed between the gait function and static balance, there were no significant correlations between the pelvic inclination, gait, and static balance. Suggesting that the pelvic inclination is not an important consideration for increasing the gait function and static balance [34].

Conclusion

Based on our findings, there was significant correlation between balance and pelvic alignment in diplegic cerebral palsy children.

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