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Correlation between Foot Progression Angle and Balance in Cerebral Palsied Children

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ABSTRACT

The purposes of this study were to assess foot progression angle and to investigate the correlation between foot progression angle of right and left lower extremities and balance in diplegic cerebral palsied children. Sixty spastic diplegic cerebral palsied children with age ranged from 5-8 years participated in this study. They were classified into three age groups of equal numbers: Group A: From 5-6 years, group B: From 6-7 years and group C: From 7-8 years. Foot progression angle of both feet was measured by using dynamic foot print and balance was evaluated using Biodex balance system equipment. Results revealed no significant difference of the mean of the foot progression angle among the three study groups for both right and left feet. Results showed that there was a positive correlation between foot progression angle of the right foot and overall stability index, antero-posterior stability index and medio-lateral stability index. On the other hand, there was no significant correlation between foot progression angle of the left foot and the same previously mentioned variables. The results of the present study indicated that foot progression angle analysis and correlation between foot progression angle of both lower extremities and balance could provide quantitative and objective information that could be used in the clinical assessment of rehabilitation strategies to detect functional abnormalities and to determine the appropriate treatment.

Key words: Foot progression angle, balance, biodex balance system, cerebral palsy, diplegia

INTRODUCTION

Cerebral Palsy (CP) describes a group of disorders of posture and movement that occur as a result of a non-progressive disturbance in the brain of the developing fetus or infant. Secondary musculoskeletal impairments, pain and physical fatigue are thought to contribute to changes in motor function in adolescents and adults with CP that may include a decline in walking (Palisano *et al.*, 2010).

Balance deficits are considered the most common problems for spastic diplegia treated by physical therapists. Therapists need to identify who has a balance problem and then decide the best approach for rehabilitation (Horak *et al.*, 2009).

Muscle imbalance, spasticity and deformities at the hips, knees and ankles contribute to the specific posture and gait patterns typical for diplegic CP as scissoring, jumping gait, crouch gait, Stiff knee, genu recurvatum and torsional deformities (Berker and Yalcin, 2010).

Rotational gait problem is a common problem in patients with CP and compromises gait efficiency and function (Gage *et al.*, 2009). Lower limbs rotational troubles in spastic diplegic CP children are frequent and difficult to identify by physical examination alone. These troubles modified level arm's length and they are important to be treated (Simon *et al.*, 2014).

Various gait patterns have been reported in ambulatory spastic diplegic children. These patterns are characterized by limited mobility in their lumbar spine, pelvis and hip joints and show limited asymmetric pelvic tilt or pelvic rotation during gait. Many of the ambulatory children with spastic diplegia are able to acquire a walk with flexed hips, knees and ankles known as crouch gait. Crouch gait has been interpreted to result from over activity or shortening of the hamstrings (Yokochi, 2001).

Although, gait in children with spastic diplegia may be variable, the most common pattern includes problems in the sagittal, coronal and transverse planes. There is a characteristic anterior pelvic tilt with a compensatory lumbar lordosis, flexed, internally rotated and adducted hips, flexed, stiff knees and equinus deformities of the ankle. This results in a pattern of gait which is inefficient and causes limitation of function (Gage *et al.*, 1996).

Children with spastic diplegia have delayed walking pattern with motor problems as paucity of movement, increased resistance to passive movement, muscle spasm, clonus, exaggerated deep tendon reflexes and absence of change muscle tone associated with change in posture (Lee *et al.*, 2013).

Foot Progression Angle (FPA) is defined as the angle between the longitudinal axis of the foot and the line of progression of the child's gait (Stanger, 2008). It represents the rotational gait deviation of the lower extremity from the tip of the femoral head to the foot. It was also defined as the angle of the foot relative to the progressive direction of the subjects during gait (Lee *et al.*, 2013).

Foot progression angle is considered as the overall effect of the rotational alignment of the lower extremity. The rotational alignment includes the degree of hip, femoral and tibial torsion that results in a position of the foot during gait (Staheli *et al.*, 1985).

Assessment is essential for deciding on the plan of treatment, as well as predicting relapse and prognosis (Abboud, 2002).

The purposes of this study were to assess FPA within three age groups and to investigate the correlation between foot progression angle of right and left lower limb sides and balance in diplegic cerebral palsied children.

MATERIALS AND METHODS

Subjects: Sixty spastic diplegic CP children participated in this study. They were equally selected from both sexes. Subjects were selected from the outpatient clinic of Faculty of Physical Therapy, Cairo University. They were classified into three age groups of equal numbers; group A aged from 5-6 years, group B aged from 6-7 years and group C aged from 7-8 years. Children were selected according to the following criteria: (a) Age ranged from five to eight years, (b) The ability to stand and ambulate without the use of an assistive device (level 2 or 3 on the Gross Motor Function Classification System), (c) Degree of spasticity ranged from 1 to 1+ according to the Modified Ashworth Scale (Bohannon and Smith, 1987), (d) The ability to follow instructions and understand commands given to them during the testing procedure and (e) Normal vision and hearing. Children were excluded if they have: (a) Convulsions, (b) Fixed contractures of lower extremities and/or (c) Surgical interventions in the lower extremities.

Sampling method: Convenient sample of spastic diplegic CP children within three age groups were selected from the outpatient clinic of Faculty of Physical Therapy, Cairo University.

Ethical consideration: Approval from the ethical committee of the Faculty of Physical Therapy, Cairo University as well as written consent from children's parents or legal guardians was obtained before starting the study.

Instrumentation and tools:

- Gross Motor Function Classification System was used to select children who can stand and ambulate without the use of an assistive device
- Dynamic footprint was used to measure FPA. The materials used for measurement and analysis of FPA were:
  - A walkway of 6 m length, 61 cm width and 5 mm height (Losel *et al.*, 1996)
  - Paper of 610 cm by 457 cm (20×15 ft) to be placed on the walkway, with adhesive tape to stabilize it
  - Tray (1 cm depth) large enough to accommodate both feet
  - Colored powder paint and talcum powder (100:1)
  - Towel and wet wipes for cleansing feet placed at far end
  - Artist fixatives spray to be sprayed over successive footprints in order to prevent smudging of the prints
  - Adhesive transparent contact plastic to be placed over each individual footprint
  - Transparent grid (parallel lines) and fine 0.5 mm water soluble pen (non-permanent marker)
  - Two stainless steel rulers and transparent plastic protractor
- Biodex balance system is a unique dynamic postural control assessment and training system (Biodex medical system, Shirly, New York). It consists of a movable balance platform which can be set at variable degrees of instability and safety support rails. This system is interfaced with computer software monitored through the control panel screen and is supplied with Cannon Bubble Jet printer to print the test results

Procedures

Study design: Across-sectional study aiming to assess FPA among spastic diplegic CP children ranging in age from 5-8 years.

Subjects recruitment: Before recruitment, a health talk was given by the researcher to parents to explain the purposes and methodology of the study. The consent forms were then given to children's parents. After collecting the consent forms, subjects were examined by the researcher for the inclusion and exclusion criteria.

Dynamic footprint procedure: This procedure was classified into two main phases:

Measurement phase:

- The paper was laid out over an elevated walkway 6 m in length and 5 mm above the floor, adhesive tape to prevent any slippage during data collection

- Each child was standing bare-feet and was allowed to walk over the walkway several times to familiarize himself/herself with the procedure
- A wet towel was placed at the base of the chair at both ends
- A tray (1 cm depth) large enough to contain both feet, containing a composite mixture of colored powder paint and talcum powder (100:1) (Curran *et al*., 2005)
- Each child was instructed to place both feet on a wet towel, then, to place them in a tray. Excess powder was gently shaken off (Taranto *et al*., 2005)
- The container was removed and the child was instructed to walk at free walking speed to the other end, for cleansing feet by wet wipes and towel
- Once adequate footprint was obtained, four successive (mid-gait analysis) footprints were identified to exclude phases of acceleration and deceleration and sprayed with artist's fixative spray in order to prevent smearing of the print and then left to dry (Curran *et al*., 2005)
- Once dry, a piece of adhesive transparent contact plastic was placed over each individual footprint before the 6 m length of paper was rolled up (Taranto *et al*., 2005)
- Each child's name was written in each paper

Analysis phase:

- A stainless steel rulers and a fine 0.5 mm water soluble pen were used to draw lines. Angles were measured with a transparent plastic protractor enabling measurement increments to 0.5°
- A transparent grid, a simple rectangle made up of parallel lines, was placed over the footprint
- The longitudinal border of the grid was aligned with the apex of the hallux and the medial side of the forefoot. To ensure parallel placement of the grid, the distance between the top and bottom margins of the grid and the border of the paper were measured
- The grid was used to draw line (A) representing the apex of the hallux (Fig. 1). A similar line (B) was drawn at the posterior aspect of the heel that was parallel to the line (A) dividing the length of the foot into three equal portions and creating lines (C) and (D) (Shores, 1980)
- The length of line (C) forefoot reference and (D) rear foot reference was measured using the outer borders of the print, each line was bisected and thus midpoints will be determined
- The medial and lateral borders of the entire footprint were defined by constructing two lines:

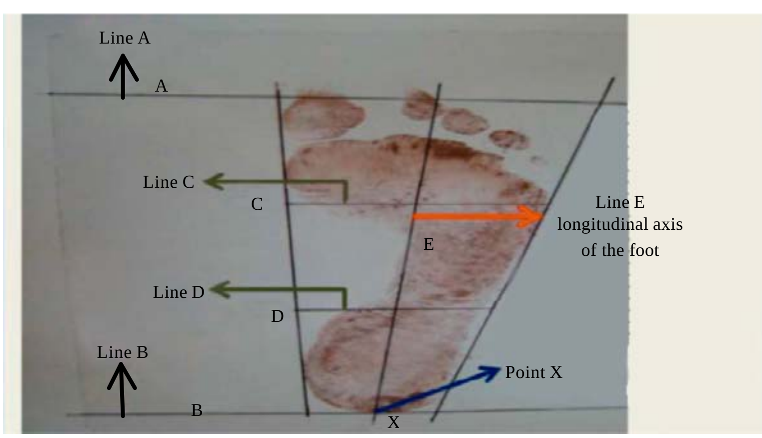

Fig. 1: Foot analysis

    - The most medial aspect of the forefoot (disregarding the toes) was marked, as was the most medial aspect of the heel. These points were connected by a line to establish the medial border of the print
    - The most lateral border of the forefoot (again, disregarding the toes) was marked, as was the most lateral border of the heel. These points were connected to establish a lateral border of the print
- A line (E) was obtained by connecting the mid-points of C and D
- Line (E) was used as the longitudinal bisection of the foot
- The point at which line (E) intersects with line (B) through the heel of the print, point (X) was chosen as the landmark for connecting other reference lines
- Providing that a point at the posterior aspect of the heel was objectively gained and identified, it was considered that a point on the heel was the most pivotal

Determining the line of progression:

- Point (X) on one footprint was connected to point (X) on the same foot creating an ipsilateral line of progression
- From point (X) a line perpendicular to the contralateral line of progression was drawn. This perpendicular line was line (H)
- The midpoint of all the obtained line (H) was measured and connected. The line obtained from all connected midpoints represented the line of progression (L). This technique produced a line of progression which altered from step to step and approximated a "line of best fit" of the sinusoidal displacement of the center of mass in walking (Wilkinson and Menz, 1997)
- Foot progression angle was measured as the angle between the longitudinal axis of the foot (line E) and a parallel line to the line of progression (line L) at (point X) as shown in Fig. 2

Dynamic balance testing procedures:

- This test was performed to examine the child's ability to control the platform's angle of tilt
- All children were given an explanatory session before the evaluation procedures to be aware about the different test steps

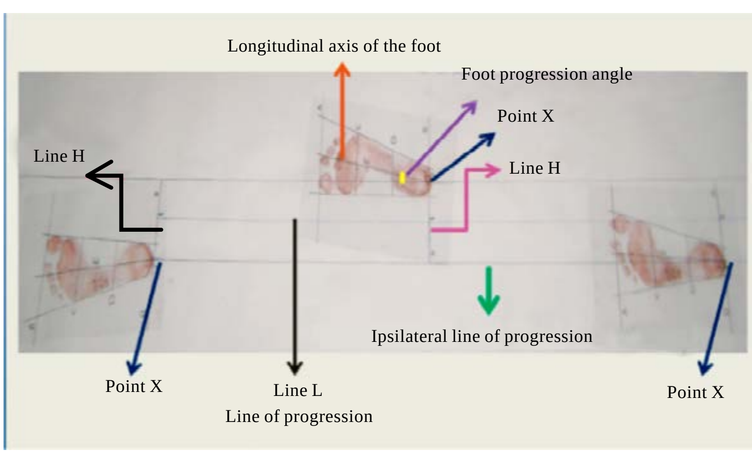

Fig. 2: Foot progression angle

- Each child was asked to stand on the center of the “locked” platform with two leg stance bare feet
- Support rails and biofeedback display was adjusted for each child according to his height to ensure comfort and safety. The display was adjusted so that the child could look straight at it

The following test parameters were introduced to the device:

- Child’s weight, height and age
- Platform firmness (stability level): All children were tested on stability level 5 (Stability levels start with level 8; the most stable platform and end with level 1; the least stable platform) for three repetitions on the same level of stability
- Test duration: Each child was tested for 30 sec

Patient centering step:

- Centering was achieved and the cursor was in the center of the display target, instructions were given to the child to maintain his/her feet position till stabilizing the platform
- As the platform advanced to an unstable state, the child was instructed to focus on the visually feedback screen directly in front of him (while standing with both arms at the side of the body without grasping handrails) and attempted to maintain the cursor in the middle of the screen
- At the end of each test trial, a printout report was obtained. This report included information as regard Overall Stability Index (OSI), Antero-Posterior Stability Index (API) and Medio-Lateral Stability Index (MLI)
- These indexes are standard deviations assessing the fluctuations around the zero point (i.e., horizontal) rather than around the group mean. The MLI and API assess the fluctuations from horizontal along the anterior-posterior and medial-lateral axes of the Biodex stability system, respectively. In contrast, the OSI is a composite of both MLI and API and thus, is sensitive to changes in both directions (Arnold and Schmitz, 1998)
- The mean values of three trials of stability indices on the measured stability level (stability level 5) were calculated for each child individually

Statistical analysis: Statistical analysis was conducted using SPSS for windows, version 18 (SPSS, Inc., Chicago, IL). One way ANOVA was used to compare among the three groups for each dependent variables (FPA of the right as well as of the left lower extremity) with alpha level 0.05. Pearson product moment correlation coefficient was used to determine the correlations between the FPA and balance parameters which includes OSI, API and MLI of the right as well as of the left lower extremity. The initial alpha level for the correlation analysis was set at 0.05.

RESULTS

Foot progression angle: The mean values and standard deviations of FPA for both right and left feet are presented in Table 1.

One-way ANOVA revealed a non-significant difference of the mean values of FPA among the three study groups for both right and left feet (Table 2, Fig. 3).

Correlation between FPA and balance parameters: The correlation between FPA and OSI, API, as well as MLI of both right and left feet was studied through the Pearson Product Moment

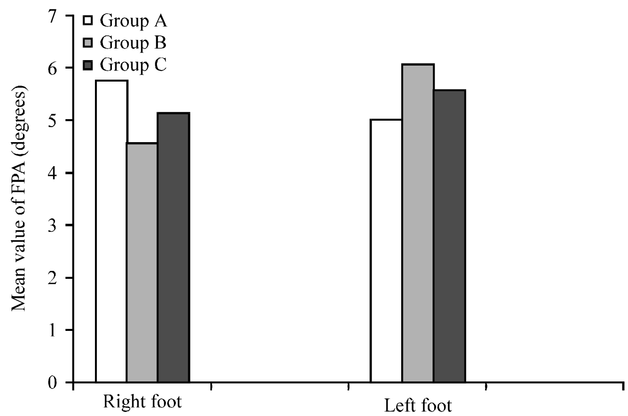

Fig. 3: Comparison between foot progression angle of right and left foot among the study groups

Table 1: Foot progression angle of both sides for all study groups

Groups	Age	Side	Foot progression angle (Mean±SD)
A	5:6	Right	5.20±2.93
		Left	4.56±0.90
B	6:7	Right	5.12±2.02
		Left	4.79±1.80
C	7:8	Right	4.23±1.57
		Left	5.57±3.02

SD: Standard deviation

Table 2: Foot progression angle of both lower extremities among the study groups

Tested foot and source	df	SS	MS	F-ratio	p-value
Right					
Between groups	2	11.292	5.646	0.946	0.396
Within groups	45	268.688	5.971		
Total	47	279.979			
Left					
Between groups	2	8.906	4.453	0.772	0.468
Within groups	49	282.801	5.771		
Total	51	291.707			

df: Degree of freedom, MS: Mean of squares, SS: Sum of squares, P: Probability value

Correlation Coefficient (r). Considering the right foot; there was a significant weak positive correlation between FPA, OSI and API, as well as MLI (r = 0.472, 0.427 and 0.301, respectively) (Table 3, Fig. 4a-c). Regarding the left foot, there was non-significant correlation between FPA, OSI and API as well as MLI (r = 0.014, 0.004 and 0.061, respectively) (Table 3, Fig. 5a-c).

DISCUSSION

The purposes of this study were to assess FPA within three age groups (5-6, 6-7 and 7-8 years) and to investigate the correlation between FPA of right as well as left lower extremity and balance in diplegic cerebral palsied children.

Foot progression angle and balance were evaluated for each participated child by the use of dynamic footprint during walking barefoot at free walking speed and Biodex balance system, respectively.

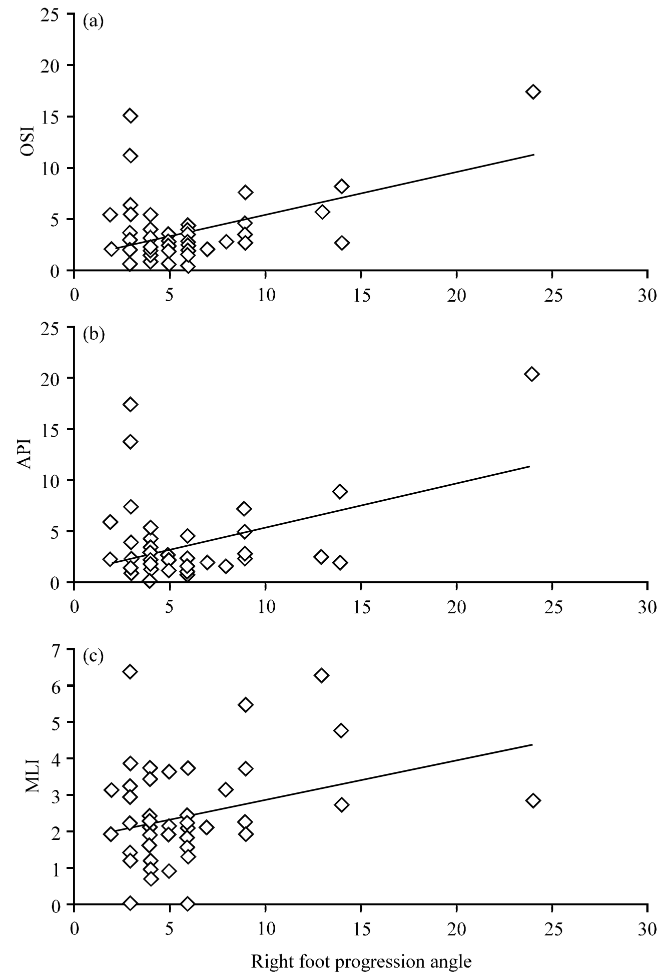

Fig. 4(a-c): Scatter plot for the correlation between foot progression angle and (a) Overall Stability Index (OSI), (b) Antero-posterior stability index (API) and (c) Medio-lateral stability index (MLI) of right side

Table 3: Correlation between foot progression angle and OSI, API as well as MLI in both right and left feet for all subjects

Side of measurement	OSI	API	MLI
Right			
r	0.472	0.427	0.301
p	0.000*	0.002*	0.032*
Left			
r	0.014	0.004	0.061
p	0.919	0.978	0.659

OSI: Overall stability index, MLI: Medio-lateral stability index, API: Antero-posterior stability index, r: Pearson correlation, P: Probability value, *Significant at alpha level 0.05

The mean values of FPA of the right foot for groups (A), (B) and (C) were 5.20±2.93°, 5.12±2.02° and 4.23±1.57°, respectively. The mean values of FPA of the left foot for groups (A), (B) and (C) were 4.56±0.90°, 4.79±1.80° and 5.57±3.02°, respectively. The correlation between FPA and OSI, API as well as MLI was 0.472, 0.427 and 0.301, respectively for the right foot and 0.014, 0.004 and 0.061, respectively for the left foot.

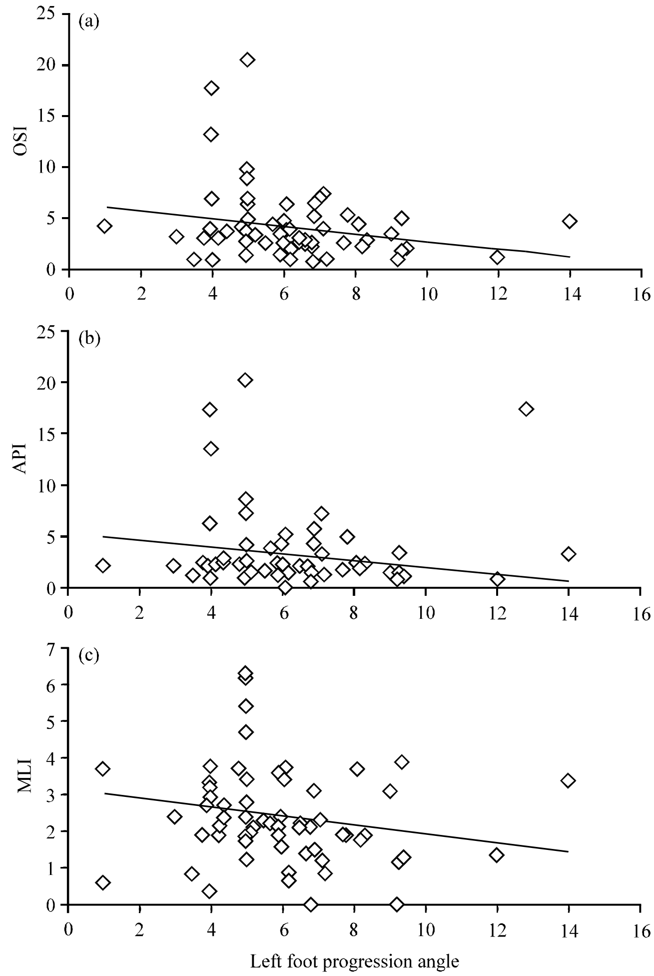

Fig. 5(a-c): Scatter plot for the correlation between foot progression angle and (a) Overall Stability Index (OSI), (b) Antero-posterior stability index (API) and (c) Medio-lateral stability index (MLI) of left side

Results revealed no significant difference of the mean values of the FPA among the three study groups for both right and left feet. Results showed that there was a positive correlation between FPA of the right foot and OSI, API as well as MLI. On the other hand, there was non-significant correlation between FPA of the left foot and OSI, API as well as MLI.

Therefore, we accepted the null hypothesis that there was no significant difference among the three age groups of diplegic cerebral palsied children regarding the FPA. We also accepted the null hypothesis that there was no correlation between FPA of the left foot and balance but reject it for the correlation between FPA of the right foot and balance in diplegic cerebral palsied children aged from five to eight years.

Assessment is essential for deciding on the plan of treatment, as well as predicting relapse and prognosis (Abboud, 2002).

Methods available in the clinical setting do not allow a dynamic assessment of the torsional profile during gait. Foot progression angle provides a quantifiable resultant of the overall effect of the rotational alignment of the lower extremity. The torsional profile describes the degree of hip, femoral and tibial torsion that results in a position of the foot during gait, referred to FPA (Staheli *et al*., 1985).

Choosing FPA for evaluation in this study comes in agreement with Losel *et al*. (1996) who stated that FPA proved as a simple and objective parameter to monitor a change in a child's gait with age. It enables the examiner to detect deviations from normal development and provides the basis for further investigation of the source of the problem. It can also serve as an instrument to determine the therapeutic success of the treatment of rotational deformities by comparison with the previous measurements which can easily be recorded. They stated that abnormality of gait, such as in-toeing or out-toeing is one of the most common concerns in diplegic cerebral palsied children. They also stated that FPA is a low cost, valuable tool in clinical gait analysis.

Lee *et al*. (2013) confirmed that FPA represents the rotational gait deviation of the lower extremity from the tip of the femoral head to the foot.

Theologis and Stebbins (2010) stated that assessment of foot pathology during walking should form an integral part of the clinical evaluation of children. One abnormality of the dynamic function of lower limbs would also interfere significantly with pediatric foot alignment (Lin *et al*., 2001).

Transverse plane abnormalities are not always recognizable through physical examination (static evaluation), instrumented gait analysis is a prerequisite for proper functional evaluation. Transverse plane kinematics provide reliable information to analyze the impact of torsional deviations on lower limb alignment and gait patterns (Viehweger *et al*., 2010).

Static measures are not good predictors of dynamic foot function and dynamic footprints have shown greater reproducibility than static footprints (Van Schie and Boulton, 2000). However, bare foot measurements are validated in the assessment of foot loading characteristics and are a valuable tool for detecting differences between two repeated measurements (Nagel *et al*., 2008).

The selection of age in this study was ranged from five to eight years comes in agreement with Chester *et al*. (2006) who stated that pediatric gait data is considered to be adult like by age three and half to four years but the mature sagittal kinetic patterns at the ankle occurred by approximately nine years of age. McSweeny (1971) also reported that approximately 80% of toe-in gait corrects spontaneously by the age of eight years.

Staheli *et al*. (1985) added that rotational abnormalities can occur at any level of the lower extremity and influence the alignment to a greater or lesser extent. Bleck and Minaire (1983) also confirmed that rotation of the hip, femur, tibia and talus influence FPA which represents the resultant of the four components mentioned.

Various types of bony deformities such as pelvic rotation, acetabular torsion, knee joint torsion between femur and tibia, ankle joint torsion between the bimalleolar axis and talus and foot deformity including forefoot adduction and abduction, could affect overall rotational alignment. In addition, spinal deformities, trunk balance and balance between external and internal rotator muscles could affect rotational gait deviations (Lee *et al*., 2013).

Foot progression angle in normal children develops parallel to the known decrease in femoral anteversion and increasing external torsion of the lower extremity with age (Staheli *et al*., 1985). The most common causes of intoeing gait in patients with diplegic CP are internal rotation of hip and internal tibial torsion (Rethlefsen *et al*., 2006).

Diplegic children show a delay in the acquisition of various gross motor functions as standing and walking. There are many factors other than structural torsional deformities of the lower extremity, such as, spinal deformity, trunk balance and rotator muscle balance, probably contribute to rotational gait problems and thus, these factors should be considered clinically (Lee *et al*., 2013).

The postural alignment of spastic diplegic children was difficult to achieve. Children with spastic diplegic CP differed from the healthy group in a number of kinematic parameters. At the pelvis, they tended to have increased anterior tilt. They demonstrated an incomplete hip extension in stance and increased hip flexion in swing. They often had increased knee flexion at initial contact. The CP group showed increased internal hip rotation in the transverse plane as well as internal FPA in stance. Children with CP were found to have a significantly decreased walking velocity, shorter step length and longer step time, when compared with the healthy group (Carriero *et al*., 2009). They added that the femoral anteversion and neck-shaft angle decrease with age, whereas the bicondylar angle increases in healthy children. The femoral anteversion was linked with FPA in healthy children. Values of tibial torsion ranged from 12 to 27 degrees at 6 years of age and increased slightly throughout growth in normal children. There was no trend in tibial torsion in subjects with CP.

Rethlefsen *et al*. (2006) reported that the most common causes of intoeing gait in patients with diplegic CP are internal rotation of hip and internal tibial torsion. However, degree of femoral anteversion and tibial torsion do not necessarily reflect the severity of the rotational gait problem which implies that intoeing might not be sufficiently explained by torsional bony deformities of the femur and tibia. This was demonstrated by Viehweger *et al*. (2010) who stated that abnormal pelvic rotation was associated with abnormal FPA in 68% of diplegic CP children.

The results of our study revealed that mean FPA was 5.20° for the right foot and 4.56° for the left at 5-6 years. It decreased non-significantly to 5.12° for the right foot and increased non-significantly to 4.79° for the left foot at six to seven years. Then it decreased non-significantly to 4.23° for the right foot and increased non-significantly to 5.57° for the left foot at 7-8 years. This come in agreement with Lee *et al*. (2013) who investigated the degree of contribution of torsional bony deformities to rotational gait parameters in patients with diplegic CP. They found that mean FPA in diplegic CP children in the age of 5-6 years was 4.81, while from 6-7 years was 5.98 and 7-8 years was 4.14° with no significant differences among age groups.

Our findings agrees with Akalan *et al*. (2013) who performed a study for discrimination of abnormal gait parameters due to increased femoral anteversion from other effects in CP. They also found that the mean FPA in children aged 6.3±1.7 years was 4.66±3.26°. According to their results, altered peak knee extension and stance-duration, increased internal hip-rotation and internal foot progression were the obvious gait parameters directly related with increased femoral anteversion in cerebral palsied children.

Our results also agree with Simon *et al*. (2014) who performed a descriptive study of lower limb torsional kinematic profiles in children with spastic diplegia. One hundred and eighty eight diplegic child with CP of type 2 and 3 according to the Gross Motor Function Classification System were retrospectively reviewed. The average age of the patient's was 11.7±0.2 years with a range from 4.25-25 years. Results showed a mean of 4-15° for FPA. Negative and positive values corresponded, respectively to internal and external rotation. They also stated that a quarter of foot progression deviations resulted from excessive ankle rotation.

Balance function is also correlated with independent walking performance in children with CP. Balance function and walking ability has various parameters. Balance includes static balance, dynamic balance, sensory organization and movement coordination. Walking performance also has several kinetic and kinematic components. However it is not clear which parameter of standing balance correlates with which parameter of walking performance (Liao *et al*., 1997). The balance function is correlated with the ability to walk independently in non-disabled children and children with CP (Woollacott and Sveistrup, 1992).

The standing and walking base in the diplegic child is narrow which makes balance difficult or impossible. The diplegic child during standing and walking often put only one heel down to the floor, usually the right one but only by rotating his pelvis to that side and with flexion of that hip. The other foot remains on its toes; the leg is internally rotated and does not take weight (Bobath and Bobath, 1990).

The factor of FPA should be taken into consideration in all foot pressure studies. The FPA has a substantial effect on foot pressure distribution, thereby affecting the meticulous balance between the medial and lateral columns of the foot (Chang *et al*., 2004).

Our findings regarding correlation between FPA and balance comes in agreement with Rai *et al*. (2006) who found that intensity patterns among normal subjects were not uniformly distributed on the plantar surface. It was also observed that among normal subjects 17% had equal pressure on both the feet, 7% showed greater pressure on left foot and 76% subjects experienced greater load on right foot.

Magge (2008) related the differences between the load on the right and left foot to the effect of handedness. He stated that the dominant side often shows a lower shoulder, with the hip slightly deviated to that side. The spine may deviate slightly and the opposite foot is slightly more pronated. The gluteus medius on the dominant side may also be weaker.

Moreover the relationship of FPA and walking speed was also linked with balance and stability. There is no real evidence that the child who in toes falls over any more frequently than any other child of the same age learning to walk (Fixsen, 1988).

Ibrahim and Sarwark (2004) found that FPA slowly externally rotates during development up until ages 11-14 years. A greater degree of toeing-out is noted to occur in the normal children to improve balance (Clarke *et al*., 1982).

Treatment of the rotational mal alignment in neurologically impaired children should consider the impact on the force redistribution of the foot in order to maintain the correction and not to worsen or even reverse the deformity of the foot (Chang *et al*., 2004).

CONCLUSION

From the obtained results of the present study, it can be concluded that FPA analysis and correlation between FPA of both lower limb sides and balance can provide quantitative and objective information that can be used in the clinical assessment of functional abnormalities and rehabilitation strategies of diplegic CP children.

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