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Secondary motor impairment in cerebral palsy: relationship to gross motor function and primary motor impairment.

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Abstract:

Background: Children with Cerebral Palsy (CP) have different types of motor impairments which divided into primary and secondary impairments. **Purpose:** to evaluate the effects of primary and secondary impairments on gross functional outcome in children with spastic CP. **Subjects and Methods:** One hundred and thirty six children with spastic CP (54 hemiplegic and 82 diplegic), aged from 2 to 5 years, all children underwent the evaluation procedures for the gross motor functions, primary and secondary impairments. The gross motor function was evaluated by gross motor function classification system (GMFCS). Primary impairment was evaluated by using Early Clinical Assessment of Balance scale (ECAB) and modified athwarth scale. Secondary impairment was evaluated by using Spinal Alignment and Range of Motion Measure scale (SAROMM), functional strength assessment scale, and early activity scale of endurance. **Results:** Diplegic CP showed higher GMFCS than hemiplegic CP level (p=0.001), lower ECAB total score than hemiplegic CP (p<0.001), and higher score of secondary impairment than hemiplegic CP (p=0.03). GMFCS showed negative correlation to ECAB total score (r=-0.7, p<0.001) and positive correlation to score of score of secondary impairment(r=0.3, p<0.006). **Conclusion:** The functional outcome of CP children largely affected by postural stability and the extent of secondary impairment.

Key-words: Cerebral palsy, primary impairment, Secondary impairment.

Introduction

Cerebral palsy (CP) is described as a group of permanent disorders of the development of movement and posture attributed to non-progressive injury or abnormal development occurring in the fetal or infant brain. The child’s gross motor functions are limited due to multiple neuromuscular and musculoskeletal impairments. Besides motor impairments, cerebral palsy has multiple associated disabilities, namely, cognitive, speech, sensory, and epilepsy disorders[1].

Cerebral Palsy causes motor impairments as weakness, spasticity, dystonia, contractures, spinal deformities, and postural imbalance[2]. These abnormalities form together so called primary and secondary impairments that intervene significantly, at different magnitudes, with the functionality of the affected children[1]. Wichers et al, (2009)[3] had evaluate muscle tone, abnormal posture, range of motion (ROM), and anthropometry in regard to motor impairments. While Kim and Park (2011)[4] measured only spasticity and muscle strength in relation to motor impairment. Tuzson et al., (2003) [5] had used electromyography to measure spasticity and found that spasticity scores were significantly correlated with the Gross Motor Function Measure (GMFM) in children with CP.

As a result of the injury/disturbance, children with CP typically present with primary and secondary impairments of body function and structure[6]. Primary impairments are problems that are apparent at the time of diagnosis, and secondary impairments are problems that occur over time, often as the result of primary impairments [7]. For children with CP, common primary impairments include aberrations in muscle tone, postural stability, and motor coordination. These are considered primary impairments because they are the direct result of the injury/disturbance that occurred in the developing brain. Over time, many children with CP will develop secondary impairments such as decreased range of motion, force production, and endurance[8].

According to Jeffres et al.(2016) [9] Early Clinical Assessment of Balance scale (ECAB) was used to measure the postural stability as a primary impairment and used the Spinal Alignment and Range of Motion Measure scale (SAROMM) to measure of spinal alignment and range of motion as a secondary impairment.

The main purpose of this work was to to evaluate the effects of primary and secondary impairments on gross functional outcome in children with spastic CP.

Study Design

This was across sectional study.

Subjects

One hundred and thirty six children with spastic CP (54 hemiplegic and 82 diplegic) were included in this study, they were selected from both sexes and there age ranged from 2 to 5 years. They were recruited from outpatient clinic at Faculty of physical therapy, Cairo University from May 2016 to December 2016. Cases with malignancy, severe perceptual defects, severe visual or auditory affection, and demonstrable decrease in IQ have been excluded.

A formal written consent has been taken from parents or care givers for all cases. The study was approved by the faculty of physical therapy ethical committee.

1-Method for evauation of the gross motor function:

- Gross motor function classification system scale (GMFCS) [10]:

The Gross motor function classification system scale is a 5-level classification system of gross motor function including the child' s performance in sitting , transfers, walking, and wheeled mobility designed for children with CP. Distinctions between levels of the GMFCS are based on the need for assistive devices and caregiver assistance.

2- for evaluation of primary impairments:

a- Modified Ashworth scale (MAS): is a measure of muscle motion and scoring the perceived resistance to movement on a scale of 1 (no increase in tone) to 5 (rigid in flexion or extension) [11].

b- Early clinical assessment of balance (ECAB) scale: Is a 13-item test that estimates postural stability for children with CP across all levels of functional ability[9].

3- for evaluation of secondary impairment:

a- Spinal alignment and range of motion measure scale (SAROMM): is a measure of spinal alignment and range of motion using standard physical therapy techniques scored on a 5-point ordinal score of 0 (normal alignment and range with active correction) to4 ("severe" fixed deformity) [12].

b- Functional strength assessment scale: Therapists completed a functional strength assessment (FSA) to obtain an estimate of strength for major muscle groups including the neck and trunk flexors and extensors, and hip extensors, knee extensors, and shoulder flexors bilaterally. Scoring options were 1 (only flicker of contraction or just initiate movement against gravity), 2 (unable to move completely against gravity), 3 (full available range against gravity but no resistance), 4 (full available range against gravity and some resistance), and5 (full available range against gravity and strong resistance) [9].

c- Early activity scale of endurance scale: Endurance for activity for this study was measured using a 4-item version of a parent-completed questionnaire, the Early Activity Scale for Endurance (EASE). Ratings made by parents are on a scale of 1 to 5 (1= never; 5 = always), with higher scores indicating greater endurance for activity[13].

Statistical analysis:

Data were presented as mean and SD for continues scale variables, and frequency with median and range for nominal and categorical variables. The correlation between variables, using Spearman's correlation, has been carried out to detect the variables to be used in regression analysis. A difference between groups has been detected by chi-square test.

The regression modules: A model of linear regression has been constructed for categorical data and a Binary logistic regression analysis was used for dichotomic variables, in order to, precisely, estimate the percentage of variance change (using adjusted R square) in the model, A p value of less than 0.05 was considered significant.

Results

The current study included cases with spastic hemiplegic (n=54, 39.7%) and diplegic (n=82, 60.3%) CP subtypes. The epidemiological data was shown in table-1.

Table-1 Epidemiological and clinical subtypes of CP

Age	3±o.8 years
Sex	Male 80(58.8%) Female 56(41.2%) Total 136 cases.

The distribution of cases accordign to GMFCS was shown in table-2. and The distribution of GMFCS levels according to CP subtype was shown in Figure-1. There was a statistically significant difference in the distribution of GMFCS with more cases on level III-V in the diplegic type and most of the cases of the hemiplegic type fall within level I.

Table- 2 Distribution of cases based onGMFCS

GMFCS*	No. (%)	Category
I (Can sit on own and moves by walking without a walking aid)	50(36.8%)	74(54.4%)
II (Can sit on own and usually moves by walking with a walking aid)	24(17.6%)	
III (Can sit on own and walk short distances with a walking aid)	36(%)26.5	62(45.6%)
IV (Can sit on own when placed on the floor and can move within a room)	22(16.2%)	
V (Has difficulty controlling head and trunk posture in most positions)	4(2.9%)	

*GMFCS= Gross Motor Classification System

Table-3 Scores of primary and secondary impairment measures

Primary impairments	Mean± SD
MA* score	
Hemiplegia	2.3±1.1 UL, 1.5±1 LL
Diplegia	2.3±1.2 UL, 1.5±1 LL
ECAB*score	56±25.6
Secondary impairments	Mean± SD
FSA*	23.7±6.3
Endurance*	12.8±2.9
SAROMM*	6.1±4.2

MA: modified athwarth scale, ECAB: early clinical assessment of balance ,FSA : functional strength assesmant, SAROMM: apinal aligment and range of motion measure.

On evaluation of primary and secondary impairment, cases with hemiplegic CP showed lesser impairment than those with diplegic type (Figure-2). There was a weak positive correlation between ECAB total score and age of cases (Figure-3).

The correlation between GMFCS level and measures of both primary (ECAB total score) and secondary (total score) impairment was illustrated in figure-4.

There was a weak negative correlation (r=-0.2), yet significant (p=0.04), between ECAB total score and total score for secondary impairment as shown in figure-5.

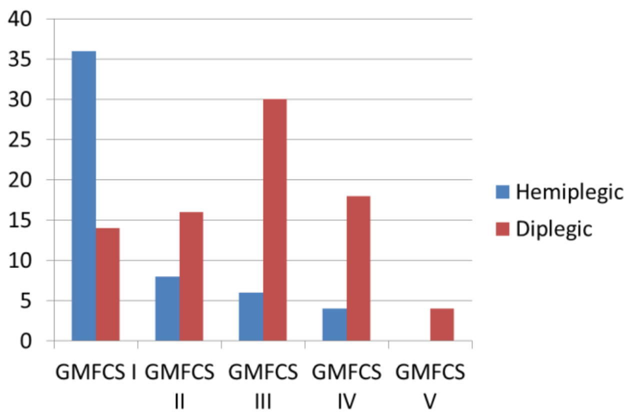
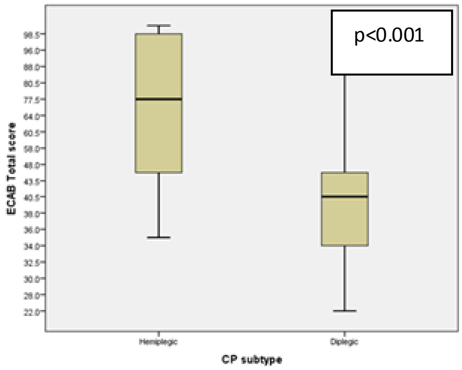
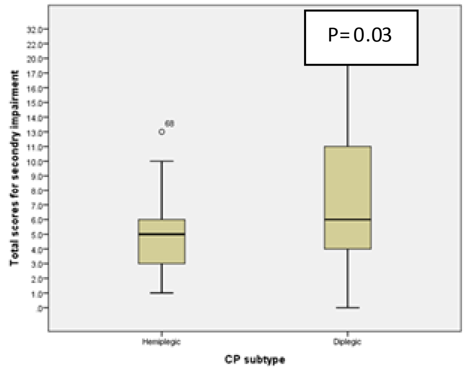


Figure-1 Distribution of GMFCS according to CP subtype.



a)



b)

Figure-2 a) Boxplots of the ECAB total scores plotted across CP subtypes. b) Boxplots of the total scores for secondary impairment plotted across CP subtypes.

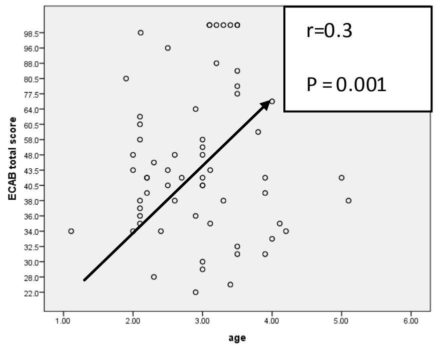
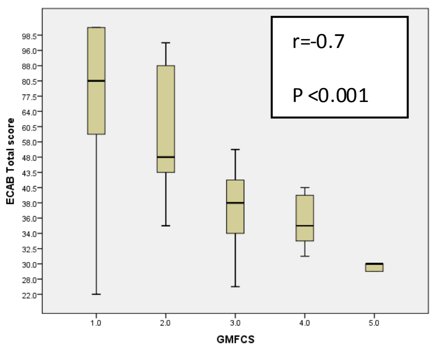
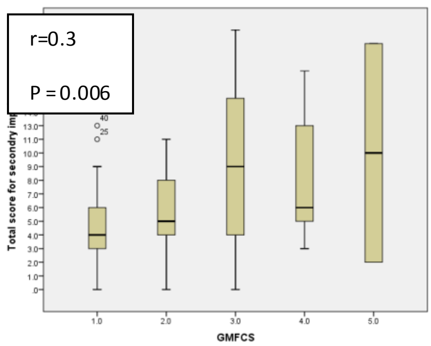


Figure-3 Scatter plot of the ECAB total scores plotted against age.



a)



b)

Figure-4 a) Boxplots of the ECAB total scores plotted across GMFCS levels. b) Boxplots of the total scores for secondary impairment plotted across GMFCS levels.

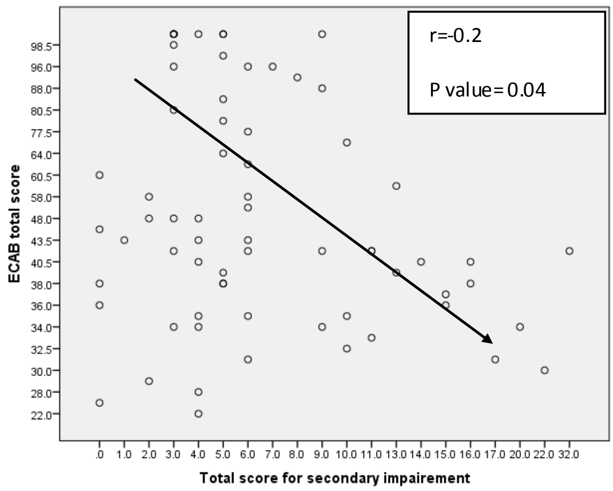


Figure-5 Scatter plot of the total scores for secondary impairment plotted against ECAB total score.

A multiple regression was run to predict total score for primary impairment (total ECAB) from GMFCS and CP subtype. These variables were statistically significantly ($p < 0.001$) predicted 52% of changes in total score for ECAB ($R^2 = 0.521$).

Another multiple regression model was run to predict total score for secondary impairment from GMFCS, total ECAB score, CP subtype, MA scale. These variables statistically significantly ($p < .0001$) and predicted 30% of changes in total score for secondary impairment ($R^2 = 0.297$).The most significant variables were CP subtype and MA score for lower limbs tone (p= 0.01 and <0.001, respectively).

A logistic regression was performed to ascertain the effects of CP subtype, MA scale, ECAB total score, and total score for secondary impairment on the likelihood that participants have severe functional disability (GMFCS IV-V). The logistic regression model was statistically significant (p=0.001). The model explained 77% (Nagelkerke R^2) of the variance in severe disability and correctly classified 90% of cases. The ECAB total score has the highest effect followed by total score for secondary impairment.

Discussion

The motor functions assessment is the corner stone in evaluation of pediatric population with CP. The relationships between motor parameters are not fully understood [14]. Although environmental and personal factors, including cognition and adaptive behavior, may affect the range of disability, the current study attempted to examine the relationships between primary and secondary motor impairment in with spastic CP children.

Østensjø et al. (2004) [15] used spasticity and ROM to assess motor impairment. It has been considered that spasticity, weakness, and restricted ROM are motor impairments in themselves; but, the researches on how they affect the functional outcome are scarce.

The main outcome of the current study was 1) to describe the distribution of primary and secondary impairments across the functional spectrum as measured by GMFCS scores, 2) to find any possible correlation between clinical variables, and 3) to evaluate the predictive power of CP subtype, and the primary impairment scores over the secondary impairment state.

Children with diplegic CP had a statistically significant higher GMFCS score than those with hemiplegic CP which was reported by Rosenbaum et al., 2010 [17] who emphasized that it is an expected result but adds to the reliability as well as the ability to predict the degree of disability based on initial clinical assessment.

The total ECAB score was found to have a modest positive correlation with age (r=0.3, p=0.001) which reflects the effect of duration over the balance system. Normally, the balancing capabilities were different between age groups but not linear with age [18]. On the other hand, maturation of postural control in children with CP has been shown to take longer to occur [19], which may be explain the weak correlation in the results of these study.

Also, the CP subtype has a modest impact on the ECAB total score and even a lesser degree to the total score of spinal alignment and range of motion measure. The GMFCS showed a strong negative correlation (r=-0.7) to ECAB total score and a lower positive correlation (r=0.3) to the total score for secondary impairments. All of these results were statistically significant and is supported by previous research, which found significant correlations between motor impairment and gross motor function[20]. Furthermore, it is in favor of the international consensus that CP is a disorder of both movement and posture[21].

Children with CP, regardless of age, showed evidence of secondary impairments, even at a GMFCS level I. This finding is in favor of results reported by Ostensjo et al., 2004 [16]. Also, a statistically significant positive correlation between the degree of primary and secondary impairments with higher GMFCS levels has been found. Again, it is expected but it goes with the assumption that more primary and secondary impairments are seen in children with greater functional limitations.

The SAROMM score has a modest negative correlation (r=-0.3) to the ECAB score alone, and within the regression model, it was found that, almost 30% of changes in secondary impairment can be explained by CP subtype, GMFCS score, tone of lower limbs, and total ECAB score.

The logistic regression found that 90% of the development of severe disability (GMFCS score IV-V) can be explained by variation in CP subtype, MA scale, ECAB total score, and total score for SAROMM.

The difference in finding small and large percentage of effect can be explained by 1) the nonlinearity of developmental process regarding both the dependent (predicted) and independent variables (predictors) [22]. 2) In addition, child development across different domains does not occur steadily, but rather shows peaks and plateaus [23, 24] that are not equal among all domains over time [25]. 3) Also, the magnitude of change in single factor is not associated with the same degree in outcome. For example, a small variation in muscle power can result into a greater gross functional change [19]. Rosenbaum et al.,(2002) [26] stated that motor function level is affected by quality and efficiency of movement. Also, the functional out come in children with CP is related to cognitive, social, and environmental factors.

In a study conducted by Bartlett et al., 2016 [20], it was found that only 9-13% of the variation in motor functions can be explained by GMFCS level and age. This study points out the multiple trajectories of motor development in children with CP and the contribution of every

gross motor parameter. These explanations raised the importance of adaptive behavior and participation in community programs.
Park and Kim (2013) [27] found that variables of motor impairment accounted for (75.5%) in gross motor function. There are studies with lower predictive power as Kim and Park (2011)[3] who reported that spasticity and strength explained only 48.8% of variation in gross motor function. The differences between those studies may be due to the sample size effect and the number of variables of motor impairment used in the regression models.

In conclusion, predicting the outcome for motor function of children with CP is a dynamic ever changing process, as both predictors and outcomes are non-linear in their relationship. In children with CP, improving postural stability and doing every effort to prevent secondary impairments should be encouraged through active interventions [28].
Activity-based strategies is the method that tackle directly the predicted variable rather that the many aspects of the predicting variables, thus, it is much easier to plan and apply [20]. Secondly, the role of activity-based intervention in enhancing neuronal plasticity has been documented in many studies [29].

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