

## ORIGINAL RESEARCH

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## A DESCRIPTIVE STUDY ON THE ASSESSMENT OF FUNCTIONAL MOTOR DISABILITY IN CHILDREN WITH CEREBRAL PALSY

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## ABSTRACT

**Background:** Cerebral palsy (CP) is one of the most common conditions in childhood causing severe physical disability. Spastic paresis is the most common form of CP. According to the topographic classification, CP is divided into spastic hemiplegia, diplegia and quadriplegia. Distribution of functional motor disability is varied in each type of CP.

**Aims:** To describe functional motor disability in children with cerebral palsy using standard scales.

**Method:** This cross-sectional descriptive study included 93 children with cerebral palsy (CP). Functional motor disability of each type of spastic CP was assessed using standard scales.

**Results:** The dominant sub-type of cerebral palsy in the present study was spastic diplegia. Most affected muscle with spasticity was gastrocnemius-soleus group of muscles. Active range of motion of foot eversion and dorsiflexion were the most affected movements in all the types of CP. In the overall sample, only 35% were able to walk independently. Majority of subjects with quadriplegia were in levels III and IV of Gross Motor Functional Classification Scale representing severe disability. There was a significant relationship observed between the muscle tone and range of motion of their corresponding joints as well as between the muscle tone of gastrocnemius-soleus group of muscles and the ankle components of Observational Gait Analysis.

**Conclusions:** Results of the present study confirms the clinical impression of disability levels in each type of CP and showed that the assessment of functional motor disability in children with different types of spastic CP is useful in planning and evaluation of treatment options.

**Key words:** Cerebral palsy, disability, standard scales, evaluation, relationship

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## INTRODUCTION

Cerebral palsy (CP) is one of the most crippling conditions in childhood causing severe physical disability. Cerebral palsy is a widespread problem and the prevalence ranges from 1.5 to more than 4 cases per 1000 live births<sup>1</sup>. In the USA, prevalence of CP has increased from 1.7-2.0 per 1000 one year survivors during the period from 1975 to 1991<sup>2</sup>. In Japan, the prevalence of CP is said to be 1.34 per 1000 six year old children. Although prevalence rate for Sri Lanka is not known, according to the available statistics in Sri Lanka, there are around 40,000 children and adults with CP in the country<sup>3</sup>. CP can be presented as spastic, dyskinetic, ataxic, hypotonic, hemiplegia, diplegic, quadriplegic or mixed types. There is diversity in distribution of motor disability in each type of cerebral palsy. Identification of the impairments such as distribution of increased muscle tone, range of motion, gait abnormalities and affected gross motor functions are useful in determining the level of disability in each type of cerebral palsy. Only a few studies have been done worldwide to describe motor impairments of children with CP<sup>4</sup>. The objective of the present study was to describe functional motor disability in children with cerebral palsy using standard scales.

## METHOD

This study was a cross sectional descriptive study. It was carried out at the Neurophysiology Clinic at the Teaching Hospital, Peradeniya, Sri Lanka. Informed consent was obtained from the parent or guardian of children included in the study. The ethical clearance for the study was obtained from the Committee on Research and Ethical Review, Faculty of Medicine, University of Peradeniya, Sri Lanka. Children with the clinical diagnosis of cerebral palsy who have been registered at the Paediatric and Orthopaedic Clinics of the Teaching Hospital, Peradeniya, Sri Lanka and referred to the Neurophysiology Clinic between the period from June 2011 to 2013 December were recruited to the study. Children with behavioural problems were excluded in this study because it is difficult to take measurements in joint range of motion, selective motor control and components of gait from the children who are not cooperative. Children or parents/guardians who did not give consent also were excluded.

### Assessment procedure

Before the assessment of motor disability, background information was collected from the parent or the guardian of the child using an interviewer administered structured data sheets. Each child's functional motor disability was

assessed using following standard scales, viz. Modified Ashworth Scale (MAS) for muscle tone<sup>5</sup>, Active (AROM) and passive (PROM) range of motion of affected joints, Selective Motor Control (SMC) of dorsiflexion<sup>6</sup>, Gross Motor Function Classification Scale (GMFCS) for gross motor functions<sup>7</sup> and Observational Gait Analysis (OGA) for walking pattern<sup>6</sup>.

### Statistical analysis

Proportion analysis was performed for the categorical variables (muscle tone, selective motor control, and gross motor functions) and mean and SD were calculated for the continuous variables (range of motion and total score of Observational Gait Analysis). Statistical relationship between muscle tone and range of motion was analyzed using t-test. Relationship between the muscle tone of gastrocnemius-soleus group of muscles and the components of Observational Gait Analysis (initial foot contact, foot contact at mid stance and timing of heel rise) were analyzed using Chi square test. Data were analysed using Statistical Package for Social Sciences (SPSS<sup>TM</sup>) for Windows Version 21.0.

## RESULTS

Motor disabilities of ninety three children with cerebral palsy were assessed in the present study. The age range of the patients in the present study was 1 to 22 years of age with a mean age of 6.68 (SD 3.78) years. There were more males (61.3%) than females (38.7%) in this group of patients with cerebral palsy. In this sample, majority of parents or guardians had an average level of education. Most of the parents (31.2 %) stated that they could identify abnormality such as delayed milestones, abnormal walking patterns and movements when the child was at or around 1 year. However some parents (6.5 %) kept their children untreated even after 5 years of age.

Spastic diplegia was the most common (63.4%) type of CP in this study group. There were only two children (2.2%) with spastic triplegia (table 1). Almost 50% of the children with CP had undergone physiotherapy treatment before taking BTX-A therapy. A fewer number of children (10.8%) had underwent orthopaedic surgeries. There were 26.9% who had not taken any type of treatment

**Table 1.** Types of CP in the study group. The number (percentage) is given.

Type of CP	Number of children (%)
Monoplegia	6/93 (6.5%)
Hemiplegia	9/93 (9.7%)
Diplegia	59/93 (63.4%)
Triplegia	2/93 (2.2%)
Quadriplegia	17/93 (18.3%)

## Muscle Tone

Children with CP in this study showed increased tone in elbow flexors, pronators, wrist flexors, hip adductors, knee flexors, ankle plantar flexor and foot invertor muscle groups. In most of the children, gastrocnemius-soleus group of muscles had been the mostly affected (94.6%) muscle group with spasticity. The least muscle group affected with spasticity was elbow flexors (9.7%). Knee flexors (55.9%) and hip adductors (49.5%) were moderately affected.

The pattern of distribution of disability in the muscle tone was varied in each CP type in the present study. Gastrocnemius-soleus was the most affected group of muscles in all the types of CP. Hip adductors were the next muscle which was mostly affected in children with spastic quadriplegia (82.4%). It was 55.9% in children with spastic diplegia. There were many children with spastic diplegia (64.4% - 38/59) and quadriplegia (76.5% - 13/17) who presented with increased muscle tone in knee flexors.

## Range of motion

AROM of foot eversion and dorsiflexion were the most affected joint ranges in all the types of CP in

the present study. In children with hemiplegia the means of AROM of eversion and dorsiflexion were 0° and 1.4° (SD 3.1°), in diplegia around 0.7° (SD 1.8°) and 1.6° (SD 3.3°) in quadriplegia 3.3° (SD 2.9°) and 1.8° (SD 2.9°) in right lower limb and 0° and 2.0° (SD 3.1°) in left lower limb respectively.

In children with quadriplegia, apart from these two joint ranges, AROM of hip abduction (mean 16.8° SD 14.8°) and supination (mean 5.0° SD 8.3°) were affected severely. There were extension lags seen in the knee (extension lag mean 31.1° SD 27.5°), elbow (extension lag mean 25.0° SD 18.0°) and wrist (extension lag mean 31.4° SD 24.7°) in right forearm and 20.4° SD 14.3° in left forearm) joints as well.

## Gait

Mean score of OGA (Observational Gait Analysis) of right lower limb was 9.4 (SD 5.8°) and 9.5 (SD = 5.9°) in the left lower limb. Perfect score of OGA in normal subject is 25 (Boyd and Graham, 1999). Mean and SD of total score of observational gait analysis for each of the type of CP are shown in table 2. It is seen that the gait was worst affected in children with triplegia and quadriplegia.

**Table 2.** Total score of OGA in right and left lower limbs. Mean and SD of total score of OGA in each type of CP are given.

Type of CP	Total score of OGA in right lower limb (mean SD)	Total score of OGA in left lower limb (mean SD)
Monoplegia	6.17 SD 3.817	7.50 SD 3.886
Hemiplegia	12.22 SD 6.300	11.22 SD 5.518
Diplegia	10.36 SD 5.880	10.51 SD 6.047
Triplegia	5.50 SD 7.778	5.50 SD 7.778
Quadriplegia	6.29 SD 4.701	6.65 SD 5.590

Distribution of the disability in various components of observational gait analysis

Severe knee crouch was observed mostly in the children with spastic quadriplegia (52.9%). Toe was the initial contact area of the foot of most of the children (70.6%) with spastic quadriplegia and it was 42.4% (25/59) in the children with diplegia. Initial foot contact through the forefoot and foot flat also was seen more in children with diplegia (49%). Most of the children with diplegia showed an equinus and foot flat with early heel rise during the foot contact at mid stance (69.5%). Most of the children with spastic quadriplegia as well showed the same pattern and it was 82.3% (14/17). There was no heel contact during the gait cycle of most of the children with spastic diplegia (45.8%- 27/59). Also 27.1% (16/59) of this type of CP had heel rise before 25% of stance phase of the gait cycle. Scissoring gait was seen in most of the children with diplegia (18.6%- 11/59) and quadriplegia (35.3%- 6/17). Also both the CP types showed

narrow base of support (children with diplegia; 13.6% and quadriplegia; 17.6%). In the population of children with spastic diplegia many presented their gait using walkers with assistance (45.8%- 27/59). Another 23 (39%) children from the same population had independent walking. In the population of children with spastic quadriplegia, 58.8% (10/17) them used walkers with assistance.

## Selective motor control of dorsiflexion

Most of the children with spastic diplegia were in level 3 of selective motor control of dorsiflexion (45.8%- 27/59) which means they could perform dorsiflexion of the ankle with the help of tibialis anterior and with flexion of hip and knee joints. In the same population, 11 (18.6%) of children showed isolated selective dorsiflexion using tibialis anterior without hip and knee flexion.

## Gross motor functions

Most of the children (45.2%) in this study group belonged to level III of Gross Motor Function Classification Scale, representing a moderate level of disability in gross motor functions. Approximately 25 % of children represented at the levels II and IV. About 6.5% of children in this study population showed normal gross motor functions (level I). Whole population of children with hemiplegia and diplegia laid between I-III levels in GMFCS. Whereas children with spastic quadriplegia was laid between III-V levels in GMFCS representing severe disability in gross motor functions.

## Relationships between muscle tone and range of motion

There were significant relationships observed between muscle tone of right/left hip adductors and PROM/ AROM of hip abduction at both lower limbs, muscle tone of right/left knee flexors and AROM of knee extension lag at both lower limbs and PROM of left knee extension lag, muscle tone of right/left gastrocnemius-soleus (GN/S) and PROM/AROM of dorsiflexion in both lower limbs, muscle tone of right/left foot invertors and AROM of foot eversion in both lower limbs, muscle tone of right/left biceps and PROM/AROM of elbow extension lag in both upper limbs, muscle tone of right/left supinators and AROM of pronation in both forearms ( $p < 0.05$ ).

## Relationship between muscle tone of GN/S and components of Observational Gait Analysis

There were significant relationships between the muscle tone of right and left gastrocnemius-soleus and the components "initial foot contact", "foot contact at mid stance", "timing of heel rise" of both right and left lower limbs ( $p < 0.05$ ).

## DISCUSSION

Present study was done to assess functional motor disability in children with different types of cerebral palsy. Among children with spastic CP in the present study, the most common sub type of CP was spastic diplegia (63.4%). Apart from our results there are no published data on CP in Sri Lanka. It was the most common sub type seen in Pakistan<sup>8</sup> and in Turkey<sup>9</sup>. However in North India, the most common sub type of CP was spastic quadriplegia and the prevalence was 51.5%<sup>10</sup>. In the present study, the next largest number of children with CP was found under the sub type spastic quadriplegia (18.5%). Some studies have reported that the second most common type of CP is spastic quadriplegia<sup>8,9</sup>. Other studies have reported that it is spastic hemiplegia<sup>11</sup>. Rests of the

types of CP in the present study were spastic hemiplegia (9.7%), triplegia 2.2% and monoplegia (6.5%). These are similar to the reported studies in Pakistan<sup>8</sup> and Turkey.<sup>9</sup>

The prevalence of cerebral palsy is greater in boys than in girls.<sup>1</sup> This is similar to the male:female ratio (1.58:1) of the present study. It was similar (1.4:1) in studies done in three states of the USA and in the Mersey region in North West England.<sup>1,12</sup> A higher male:female ratio (2.12:1) was observed in a study done in the West of Ireland between the period of 1990-1999.<sup>11</sup> However a study conducted in the UK has reported a smaller male:female ratio (1.15:1).<sup>13</sup> Studies argue that the disparity between male and female can be due to some important neurobiological differences between males and females with respect to brain injuries.<sup>14</sup>

In all types of CP in the present study the most affected muscle with spasticity was gastrocnemius-soleus group of muscles. In children with spastic hemiplegia, the next affected muscle groups were knee flexors in the lower limb and pronators in the forearm. This is an important indicator when treating children with spastic cerebral palsy with BTX-A or physical therapy. Studies recommend that the most appropriate target muscles should be focused when administering BTX-A injection<sup>15</sup>. Therefore according to the results of the present study more consideration should be given to gastrocnemius-soleus group of muscles and knee flexors when treating with botulinum toxin type-A injection to the lower limbs of children with spastic hemiplegia. This finding agrees with a recommendation given by a review which states that when treating a child with spastic hemiplegia the primary target muscle is the calf and the secondary is the hamstrings<sup>15</sup>.

In the present study AROM of foot eversion and AROM of dorsiflexion were the most affected joint ranges. Their PROM was less and they were approximately the half of the ranges seen in a normal individual. This reflects the involvement of gastrocnemius-soleus group of muscles. In children with spastic diplegia, AROM of ankle dorsiflexion and foot eversion have been affected severely. In these children AROM of hip abduction was affected next. These findings are related to the increased spasticity present in the gastrocnemius-soleus group of muscles and hip adductors in the children with spastic diplegia. Similarly both dorsiflexion and hip abduction were affected in the children with quadriplegia. Apart from those they presented with knee extension lag (approximately 30°). In the same group there was a pronounced elbow extension lag presented when moving passively as well as actively. Active supination and wrist



extension were severely affected in this study group. These findings are useful in planning and evaluation of interventions for children with CP. More focus should be given to gastrocnemius-soleus group of muscles, knee flexors and hip adductors when treating children with spastic diplegia and apart from these three muscles, muscle tone of elbow flexors, forearm pronators and wrist flexors should be considered in children with spastic quadriplegia.

Findings on overall gait confirm the clinical impression of variation of gait abnormality present in each type of CP. It is said that gait is more affected in children with quadriplegia and least affected in children with hemiplegia. When considering the components of observational gait analysis, severe crouch was seen in children with spastic quadriplegia. Possible reason for this may be the increased muscle tone of knee flexors seen in children with spastic quadriplegia. Findings of the present study related to the presence of equinus and foot flat while walking confirm that the muscle tone of gastrocnemius-soleus group of muscles have an influence on heel-toe pattern of walking in children with both diplegia and quadriplegia. The presence of scissoring gait in children with spastic quadriplegia and diplegia indicates the spasticity in adductor muscles. The affected muscle groups in each type of CP can be easily determined by observing the abnormality in the components of observational gait analysis. This will be very useful in determining the most appropriate muscle group when administering BTX-A injection as well as in planning a gait training program.

Results related to the relationships between muscle tone of upper and lower limb muscles and their corresponding joint range of motion in the present study are similar to the results reported in a study done in Norway<sup>4</sup>. They have observed a moderate correlation between muscle tone of adductors and ROM of abduction, muscle tone of gastrocnemius-soleus and ROM dorsiflexion. This relationship will be a good predictor when assessing the changes in joint range of motion following BTX-A injection to the corresponding muscle. Studies have reported that reduction of spasticity in gastrocnemius-soleus group of muscles improves the selective motor control of dorsiflexion<sup>4</sup>. There was no evidence found in related to this in the present study. However significant correlations were observed between the muscle tone of gastrocnemius-soleus and components of observational gait analysis such as initial foot contact, foot contact at mid stance and timing of heel rise. Changes in these components of the gait cycle can be reliably used

to assess the outcome of BTX-A therapy given to gastrocnemius-soleus group of muscles.

## CONCLUSIONS

Study outcomes prove that the order of distribution of topographic classification of cerebral palsy in the study population seems to be similar to the values reported in other countries but the amount of distribution of each type vary from country to country. This study confirms the clinical impression of disability levels in each type of CP. Also the results of the present study help in selecting the most appropriate muscle in each type of CP when administering BTX-A injection.

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