Title: Gross motor function in cerebral palsy: the association with motor type and topographical distribution

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Abstract

Background: Cerebral palsy is a major cause of disability in children, and information about factors influencing prognosis of gross motor function is necessary to establish realistic physiotherapy treatment goals.

Objectives: To assess the gross motor function of children with cerebral palsy and determine the association with motor type and topographical distribution.

Methods: This is a cross-sectional study of children with cerebral palsy seen at the outpatient physiotherapy departments of selected hospitals and at the special schools for children with special needs in Osun State, Nigeria. Gross motor function ability was categorized using the Gross Motor Function Classification System (GMFCS).

Results: A total of 154 children (96 males and 58 females) aged 1 – 12 years (mean 5.62 ± 4.28 years) were recruited for this study. Twenty participants (13%) had severe deficits (GMFCS level V), 54 (35.1%) had moderate deficits (GMFCS level III), while 8 participants (5.2%) had mild deficits (GMFCS level I). Based on topographical distributions and motor type, many of the participants had quadriplegia (67.5%) and the spastic subtype (71.4%). Gross motor function ability had a moderate positive association with motor type ($\rho = 0.484$, $p = 0.031$) and a weak association with topographical distribution ($\rho = 0.239$, $p = 0.020$).

Conclusion: This study concluded that motor type and topographical distribution are factors associated with gross motor function of children with cerebral palsy. This finding may have implications in guiding expected outcome, improving the strategies of physiotherapy interventions, and in counseling families of these children.

Keywords: Cerebral Palsy, Children, Motor Function, Disability

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Introduction

Cerebral palsy (CP) is "a group of permanent disorders affecting the development of movement and posture and causing activity limitations that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain" (Rosenbaum, et al., 2007). It has been described as "an umbrella term covering a group of non-progressive, but often changing, motor impairment syndromes secondary to lesions or anomalies of the brain arising in the early stages of its development" (Mutch, et al., 1992). CP is characterized by motor impairment and can present with global physical and mental dysfunction (Krigger, 2006). It is a major cause of childhood disability and one of the most common life-long developmental disorders in childhood.

CP occurs in about 2 to 2.5 per 1,000 live births worldwide and is the most common childhood neuromuscular condition seen by paediatric rehabilitation practitioners, including physiotherapists (Hanna, et al., 2008). The prevalence of CP is higher in the more socio-economically deprived populations of the world (Lagunju, Adedokun, and Fatunde, 2006). CP is understandably more common in under-developed communities, with their low levels of medical care and after-care (Nottidge and Okogbo, 1991).

Although these clinical syndromes are often not clear, recognition of the dominant motor types and topography has been important for research into causal pathways and possible prevention, correlation with brain imaging, and for establishing a prognosis and setting management goals and strategies (Howard, et al., 2005).

The Gross Motor Function Classification System (GMFCS) (Palisano, et al., 1997) was developed in response to the need to have a standardized system for describing and classifying the severity of movement disability in children with cerebral palsy in one of five ordered levels

(Morris and Bartlett, 2004). Use of the GMFCS currently relies on a health professional to undertake clinical observation or review descriptive medical records that include details of a functional assessment (Morris, Galuppi, and Rosenbaum, 2004). According to the designers of the GMFCS, most children will remain at the same level from age 2 to 12 years, which makes it possible to try to predict gross motor development (Carnahan, Arner, and Hägglund, 2007).

To understand the clinical picture of CP, there is the need to know the value of characteristics at the impairment level, such as the number of limbs with impaired motor control or the type of motor disorder, and its severity at the function level (Gorter, et al., 2004). Few Nigerian studies (Hamzat and Fatundimu, 2008; Tella, et al., 2011; Eseigbe, et al., 2012) have assessed gross motor function ability in children with CP using the GMFCS. Hamzat and Fatundimu (2008) compared the assessment of motor functions in CP by caregivers (using GMFCS Family Questionnaire) and physiotherapists (using GMFCS), and their findings showed consistency in assessments. Tella et al., (2011) assessed the impact of cerebral palsy on health-related quality of life of Nigerian children and used the GMFCS to assess and classify the severity of the disability. Eseigbe et al. (2012) compared the Expanded and Revised Gross Motor Function Classification System (GMFCS-E&R) and Manual Ability Classification System (MACS) in the assessment of motor function in children with CP. The influence of motor type or number of limbs impaired with gross motor function was not considered in these previous studies. Information about factors influencing prognosis of motor function is necessary to establish realistic treatment goals. Therefore this study was designed to assess the gross motor function ability in children with CP in selected hospitals and schools for children with special needs. The differences in gross motor function among groups (motor type, topographical distribution) and associations with motor type and topographical distribution were also determined.

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Methods

This was a cross-sectional study involving 154 (96 males and 58 females) children with CP. Participants were consecutively recruited from the outpatient physiotherapy clinics of 3 hospitals and 5 schools for children with special needs in Osun state using non-probability sampling of convenience. The hospitals were Obafemi Awolowo University Teaching Hospitals Complex (OAUTHC), Ile-Ife and Ilesa units, and Ladoke Akintola University of Technology (LAUTECH) Teaching Hospital, Osogbo. The schools for children with special needs were Baptist Central School, Ile-Ife; St. Paul Special School, Ayegbaju; Special School for the Handicapped, Ile-Ife; Special School for the Handicapped, Osogbo; and Ijesa Special School, Ilesa. Osun State is located in the South Western part of Nigeria. Nigeria has a population of over 130 million people, and people in Osun state constitute 3,416,959 million of this population (NPC, 2006). For this study, children with CP were selected using the following inclusion criteria: adequate medical record showing a clinical diagnosis of CP by a paediatrician or neurologist and age of between 1 and 12 years. Children with spina bifida, chromosomal anomalies or any other accompanying neuromuscular disorders were excluded from the study. Assessments were done in the physiotherapy out-patient clinics of the selected hospitals and clinics of the schools for children with special needs.

The protocol for this study was approved by the Ethics and Research Committee of the Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife. All potential participants were screened and only those with medical records that showed the diagnosis of CP by a paediatrician or neurologist were recruited. Diagnosis was confirmed by the researchers through relevant clinical tests and physical examinations that included observation of delayed motor development, abnormal muscle tone, abnormal posture and assessment of persistent infantile reflexes such as

asymmetric tonic neck reflex and Babinski reflex. The definition of CP proposed by Bax, et al, (2005) that "cerebral palsy (CP) describes a group of disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, cognition, communication, perception, and/or behaviour, and/or by a seizure disorder" was used in this study.

The parents or caregivers of potential participants received verbal information and explanation about the purpose and procedure of the study before giving informed consent. The ages of the participants were obtained from the parents or caregivers and recorded. One of the researchers physically examined the participants and recorded the motor type and topographical distribution. Motor types were classified as spastic, dyskinetic, ataxic or mixed, based on clinical features described by Krigger (2006). For the spastic type, the affected limbs demonstrated increased deep tendon reflexes, tremors, muscular hypertonicity, weakness, and a characteristic scissors gait with toe-walking. The dyskinetic type of cerebral palsy was characterized by abnormally slow, writhing movements of the hands, feet, arms, or legs that were exacerbated during periods of stress and absent during sleep. Ataxic cerebral palsy predominately impairs balance and coordination. The patients walk with a wide-based gait and have intention tremors that complicate performance of daily activities requiring fine-motor function. Children with mixed type of CP had dystonia, mild spasticity, and/or athetoid movements. Spastic motor types were further categorized according to topographical distribution as hemiplegia, diplegia or quadriplegia.

The gross motor function ability was categorized by one of the researchers using the GMFCS developed by Palisano, et al., (1997). The GMFCS is a 5-level descriptive scale used among

children with CP to categorize motor abilities during successive age intervals (Rosenbaum, et al., 2002). Participants were assessed with GMFCS using the appropriate age-specific assessment section to categorize subjects into their functioning levels by observing self-initiated movements. The children were classified based on their usual performance using sitting, walking, and assistive devices as key descriptors of the level (severity) of disability over four age categories: <2 years, 2–4 years, 4–6 years, and 6–12 years.

Data Analyses

Descriptive statistics of mean, standard deviation, frequency and percentage were calculated for characteristics of the participants (age category, gender, type of CP, topographical distribution, disability). Kruskal-Wallis test was used to determine the differences in gross motor function abilities among groups (motor types and topographical distribution). Spearman correlation analysis was used to determine the relationship between gross motor function ability and selected variables (motor type, topographical distribution). All statistical analyses were carried out using Statistical Package for Social Sciences (SPSS) 16.0. Significance was set at 0.05 α-level.

Results

The ages of the participants ranged from 1 to 12 years (mean= 5.62±4.28). Ninety-six (62.3%) of the 154 children were males while 58 (37.7%) were females. The distribution of age, sex, motor type, topographical distribution and GMFCS categories are shown in Table 1. Using the distribution according to the motor type, children with spastic motor type were the majority (71.4%), while those with mixed type (6.4%) were the least in number. Twenty participants (13%) had severe deficits (GMFCS level V), 54 (35.1%) had moderate deficits (GMFCS level III) while 8 participants (5.2%) had mild deficits (GMFCS level I).

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Table 1: Characteristics of the participants

Variables	Frequency	Percentage
Age group (yrs)		
< 2	38	24.6
2-4	34	22.1
4-6	22	14.3
6-12	60	39
Gender		
Male	96	62.3
Female	58	37.7
Type of CP		
Spastic	110	71.4
Hemiplegia	20	13
Diplegia	22	14.3
Quadriplegia	68	44.2
Dyskinetic	18	11.7
Ataxic	16	10.4
Mixed	10	6.4
Topographical distribution		
Hemiplegia	23	14.9
Diplegia	27	17.5
Quadriplegia	104	67.5
GMFCS category		
I	8	5.2
II	48	31.1
III	54	35.1
IV	24	15.6
V	20	13

Key: GMFCS- Gross Motor Function Classification System

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Table 2: Distribution of GMFCS categories according to gender, motor type and topographical distribution.

Key: GMFCS- Gross Motor Function Classification System

Variables		**GMFCS n (%)**				
		I	**II**	**III**	**IV**	**V**
Gender						
Male	96	3 (3.1)	30 (31.3)	31 (32.3)	20 (20.8)	12 (12.5)
Female	58	5 (8.6)	18 (30)	23 (39.7)	4 (7)	8 (13.7)
Age category						
< 2	38	2(5.3)	10 (26.3)	11 (29)	6 (15.8)	9 (23.7)
2-4	34	1 (2.9)	12 (35.3)	8 (23.5)	8 (23.5)	5 (14.7)
4-6	22	1 (4.6)	8 (36.4)	5 (22.7)	4 (18.2)	4 (18.2)
6-12	60	4 (6.7)	18 (30)	30 (50)	6 (10)	2 (3.3)
Motor type						
Spastic	110	5 (4.6)	30 (27.3)	42 (38.2)	20 (18.2)	13 (11.8)
Dyskinetic	18	1 (5.6)	10 (55.5)	3 (16.7)	2 (11.1)	2 (11.1)
Ataxic	16	0 (0)	8 (50)	4 (25)	2 (12.5)	2 (12.5)
Mixed	10	2 (20)	0 (0)	5 (50)	0 (0)	3 (30)
Topographical distribution						
Hemiplegia	23	4 (14.3)	5 (17.9)	3 (13)	7 (25)	4 (14.3)
Diplegia	27	2 (7.4)	4 (14.8)	11 (40.7)	4 (14.8)	6 (22.2)
Quadriplegia	104	2 (1.9)	39 (37.5)	40 (38.5)	13 (12.5)	10 (9.6)

Among the children with spastic motor type, 45 (40.9%) had moderate deficits (GMFCS III), 13 (11.8%) had severe deficits (GMFCS V) and only 5 (4.6%) had mild deficits (GMFCS I). The highest proportion of male (34.9%) and female (46.6%) children were categorized as GMFCS III and the highest proportion of hemiplegic (28.6%), diplegic (40.7%) and quadriplegic (42.3%) children were categorized as GMFCS III (Table 2).

There were significant correlations ($p < 0.05$) between gross motor function abilities and the selected categories (motor type and topographical distribution) (Table 3). There was, however, no significant difference in the gross motor function abilities of children with CP with different motor types ($\chi 2 = 6.504$, $p = 0.170$) and topographical distributions ($\chi 2 = 1.862$, $p = 0.752$).

Table 3: Spearman correlation analysis of gross motor function showing associations with motor type and topographical distribution.

Variables	**ρ**	***p value***
Motor type	0.484	0.031
Topographical distribution	0.239	0.020a

Discussion

CP, one of the most common physical disorders in children, represents the most frequent diagnosis of children who receive physiotherapy (Tieman et al, 2004). This study assessed the gross motor function abilities of children with CP using the GMFCS and determined the associations with motor type and topographical distribution. The results of our study showed that the male-to-female ratio of children with CP was 1.7:1. This is similar to the results of previous studies in this environment (Sathiakumar and Yakubu, 1987; Nottidge and Okogbo, 1991; Hamzat and Fatudimu, 2008; Ogunlesi, et al., 2008; Belonwu, Gwarzo, and Adeleke, 2009). Male children have CP more frequently than females, but the reason is not certain. A concept that emerged

from a study by Johnston and Hagberg (2007) is that there are important neurobiological differences between males and females with respect to their response to brain injuries.

The results of this study showed that children with the spastic type of CP were the most among the study population. This is in agreement with the observations made in previous Nigerian studies (Nottidge and Okogbo, 1992; Ogunlesi, et al., 2008; Belonwu, Gwarzo, and Adeleke, 2009; Hamzat and Fatudimu, 2009) and internationally (Mutch, et al., 1992; Sigurdardottir,et al., 2009) andconfirms that the most common subtype of CP generally is the spastic type (71.4%). Of the children who had the spastic subtype of CP, most had bilateral affectation. This result is similar to the results in these other previous studies.

Many of the children (67.5%) had quadriplegia, which is the type of dysfunction most often cited in the literature on CP (Pfeifer, et al., 2009). This is in support of previous studies (Caram, et al., 2006; Hamzat and Fatudimu, 2008; Ogunlesi, et al., 2008; Pfeifer, et al., 2009). The children with mixed subtype of CP were the least in number in our study (6.4%). This finding is contrary to the findings in the study by Belonwu, Gwarzo, and Adeleke (2009). They reported the physiologic forms of CP observed in their study as spastic (41.7%), mixed (29.8%), hypotonic (21.9%) and dyskinetic (6.6%). The difference in results may be the grouping of the motor types. None of the children with CP was classified as hypotonic in our study. About one fifth of their participants had hypotonic CP motor type. The revised classification defines 3 main categories of motor disorder in CP based on the predominant neuromotor abnormality (spastic, dyskinetic, ataxic) apart from the mixed type. The reason for not having any hypotonic CP type in our study may be the ages of our participants (≥ 1 year). Children (infants) with CP usually have a period of hypotonicity during the early months of life (Berker and Yalcin, 2005). The hypotonic motor type has been found to be mostly a transition stage in the development of athetosis or spasticity

(Günel, 2011). Children with the ataxic type are hypotonic during the first 2 years of life. Toward the age of 2 to 3 years, the muscle tone becomes normal and ataxia becomes apparent (Berker and Yalcin, 2005). Another reason for the difference in results may be the different research methods employed. Our study was a prospective cross-sectional study, while theirs was a retrospective study. They could only depend on the recorded diagnosis in the medical records of their patients.

The results of the classification of gross motor function in this study showed that 36.3% of the children were categorized into GMFCS levels I and II and 35.1% into GMFCS level III. This is contrary to the findings in the study by Nordmark, Hägglund, and Lagergren (2001) who reported that over half (59%) of their participants were categorized into levels I and II and 14% into level III. In partial agreement with their findings, our results showed that 28.6% were categorized into GMFCS levels IV and V. The findings of this present study are also contrary to the report in the study by Howard, et al. (2005) whose findings varied from 35% of their participants classified into GMFCS level I and 18% into GMFCS level V. Most children with CP in our study were evaluated as GMFCS II –IV, which is different from findings in other studies (Himmelmann, et al., 2006; Beckung, et al., 2007; Voorman, et al., 2007; Pfeifer, et al., 2009). A reason for not having many severely disabled children in this study may be that some families in this environment hide their severely disabled children in their homes and often exclude them from family and community activities. Also, children with mild disabilities are not often brought for physiotherapy treatment in this environment.

No significant difference was found in the gross motor functions when the children were categorized according to motor type and topographical distribution. There were significant associations between gross motor function and the categories considered; motor type and

topographical distribution. The correlation between gross motor function and motor type is expected because GMFCS is based on motor performance. The result is similar to the findings in the study by Shevell, Dagenais, and Hall (2009). It has been shown that determining CP motor subtype has etiological implications and appears to have implications for the burdens of comorbidity (Shevell, Dagenais, and Hall, 2009). The GMFCS makes it possible to set functional rehabilitation goals for each motor level in different age groups. It can help health professionals working with children with CP make sure they give appropriate care to the children based on their functional level and age (Pfeifer, et al., 2009). We assessed gross motor function of children with CP to have a better understanding of the factors that influence it so as to improve the strategies of physiotherapy interventions. Motor type and topographical distribution should be accurately determined and noted during the evaluation of children with CP in the process of rehabilitation. Motor type is an important factor in the gross motor function abilities of children with CP. Therefore, physiotherapists and other rehabilitation experts should consider the gross motor function ability in the process of managing children with CP with different motor types.

A limitation of this study was that the sample was of convenience. The participants were recruited consecutively as they became available based on the inclusion criteria. The authors therefore recommend that further studies address the problem of external validity. Further work is also needed to explore other factors that may affect gross motor function in children with CP with varying degrees of disabilities.

Conclusion

This study concluded that motor type and topographical distribution influence gross motor

function of children with CP. This may have implications in guiding prognosis, improving the strategies of physiotherapy interventions and in counseling families of children with CP.

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Conflict of interest: None declared.

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