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Relation Between Objectively Measured Growth Determinants and Ambulation in Children with Cerebral Palsy

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Aims: Cerebral palsy (CP) is a well-known neurodevelopmental condition beginning in early childhood and persisting throughout one's life span. Feeding problems and eating impairments in CP children are well documented in the literature. The aims of our study were to determine the prevalence of linear growth retardation and the other growth determinants in this patient group and to identify the contributing factors and their relationship with ambulation.

Materials and Methods: A cross-sectional and prospective study was carried out between March 2007 and July 2007 in our pediatric inpatient rehabilitation service, and a total of 34 CP patients (22 male, 12 female) were enrolled into the study. Anthropometric measurements (weight, height, upper arm length, skinfold thickness) were performed to clarify the growth and nutrition determinants.

Results: According to our results in the total sample, highly positive correlations were found between anthropometric measurements and ambulatory status, whereby with higher levels of ambulation (community walker), the percentiles of growth parameters were increased. Additionally, nutritional status was not significantly affected by ambulatory skills but this relation did not reach statistical significance.

Conclusions: We concluded that ambulation level is highly related with growth determinants, or vice versa. Early awareness of physicians on this topic is important and can possibly make great differences in the stature and neurologic well-being of these patients.

Key Words: Cerebral palsy, ambulation, growth

Serebral Palsy'li Çocuklarda Objektif Ölçümlü Gelişim Belirteçleri ile Ambulasyon İlişkisi: Zayıf İyidir?

Amaç: Serebral palsi, erken çocukluk döneminde başlayan ve tüm yaşamı etkilediği iyi bilinen nörogelişimsel bir hastalıktır. SP'li çocuklardaki beslenme ve yeme problemleri literatürde oldukça geniş düzeyde bulunmaktadır. Çalışmamızın amacı bu hasta grubunda gelişim parametrelerinin geriliğinin bulunup bulunmadığını tanımlamak, ve varsa prevalansını tanımlamak ve ilişkili faktörleri ortaya çıkarmaktır.

Materyal ve metod: Çalışmamıza Mart 2007 ile Temmuz 2007 tarihleri arasında pediatrik rehabilitasyon servisimizde yatarak rehabilite edeilmek üzere kabul edilen 34 CP'li hasta dahil edildi. Hastalarımızın gelişim ve beslenme düzeylerini tanımlayabilmek için antropometrik (kilo, boy, kol boyu uzunluğu) ölçümleri yapıldı.

Bulgular: Sonuçlarımıza göre, ambulasyon düzeyleri ile antropometrik ölçümler arasında pozitif yönde korelasyon tespit edildi. Ambulasyon seviyesi yüksek olan çocukların gelişim parametreleride ileri düzeydeydi. Nutrisyonel durum ile ambulasyon düzeyi arasında bir ilişkiye rastlanmadı.

Sonuç: Ambulasyon seviyesi gelişim düzeyi ile ileri düzeyde ilişkidedir, ya da tersi de doğru olabilir. Gelişim ve beslenme parametreleri açısından dikkatli ve uyanık olunması bu hasta grubundaki çocukların nörolojik ve bedensel iyilik halinde büyük değişiklikler yapacağı düşüncesindeyiz.

Anahtar Sözcükler: Serebral palsi, ambulasyon, büyüme parametreleri

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Introduction

Cerebral palsy (CP) is a well-known neurodevelopmental condition beginning in early childhood and persisting throughout one's life span (1). The average incidence is approximately 2-2.5 per 1000 live births, and the prevalence in our country is 1.5-4 per 1000 live births through the ages 2 to 16 (2-4). The newest definition of this umbrella term describes a group of permanent disorders of the development of movement and posture causing activity limitation, which are attributed to non-progressive disturbances

that occurred in the developing fetal or infant brain. The motor disorders of CP are often accompanied by disturbances of sensation, perception, cognition, communication, and behavior, by epilepsy, and by secondary musculoskeletal problems (1). From this point of view, CP seems more and more complicated to the doctors involved in the treatment of these patients with multiple problems. One of the confusing areas in these patients is the relation between poor growth and severity of the disease. The incidence of undernutrition and poor growth is related not only with severe forms but also with mild forms of CP (5).

Throughout the world, parents and doctors have focused on growth determinants of healthy children. However, in the routine follow-up of CP children, medical staff focus primarily on other problems such as epilepsy, and musculoskeletal, auditory and visual problems. In addition to these, eating impairments and feeding problems are incidentally realized by their doctors. The relationship between growth determinants and feeding problems and eating impairments has not been sufficiently analyzed and as a result has had a limited effect on the therapy plan.

The aims of our study were to determine the prevalence of linear growth retardation and the other growth determinants in this patient group, and to identify the contributing factors and their relationship with ambulation.

Materials and Methods

A cross-sectional and prospective study was carried out between March 2007 and July 2007 in our pediatric inpatient rehabilitation service. Our rehabilitation hospital is a 200-bed hospital and 20% of the beds are occupied by pediatric patients. It is the largest center that serves a high number of patients requiring rehabilitation. Our pediatric rehabilitation department admits patients from the entire country regardless of gender or concomitant medical problems. The center provides information and offers treatment on an overnight and/or monthly basis to patients and one of the members of the family or the legal guardian of the disabled child. Pediatric rehabilitation patients (CP, meningomyelocele, spinal cord injury) are often referred to our center by pediatric neurologists, pediatricians, and family practitioners for rehabilitation. The degree of functional dependency is not a criterion for admission. However, the patient's ability to communicate is an admission criterion because the successful outcome of the rehabilitation program depends largely on active participation of the patient. In pediatric patients who cannot communicate, the rehabilitation program is based on the education of the family or the caregiver on positioning, splinting (if necessary), passive range of motion exercises, daily routine care, feeding solutions, and speech and dietary therapy. If the patient can actively participate in the rehabilitation program, intensive rehabilitation is possible, in addition to the education of the family provided by the same team members. The hospital offers a day school for all ages and has three teachers who are specialized in the education of handicapped children. The teachers also participate in the education of family members.

Subjects

Thirty-four patients between the ages of 2-12 were enrolled in the study and the study population consisted of different types of CP. Exclusion criteria included those with known chronic illnesses that could independently contribute to poor growth (cardiac, renal, pulmonary, gastrointestinal tract and endocrine diseases or known syndromes) and long-term medication known to affect growth, such as steroids. The study was approved by hospital's ethics committee and informed consent was obtained from the parent or legal guardian.

Overview of Procedures

A total of 34 CP patients (22 male, 12 female) were enrolled into the study. A detailed neurological examination was done and the patient group was divided into groups on the basis of type and body distribution of muscle tone abnormality (spastic quadriplegia, spastic triplegia, spastic diplegia, spastic hemiplegia, dyskinetic, mix). Gross Motor Functional Classification System (GMFCS) was recorded as ambulation level for age (6). Ambulatory status was also noted as wheelchair-bound, household walker with braces, household walker without braces, or community walker. All children were divided with respect to severity of disability (severe, moderate and minor) (7).

Anthropometric measurements were performed to clarify the growth and nutrition determinants. Growth was determined by measurement of weight (W), height (H) and body mass index (BMI), and linear growth was assessed by upper arm length (UAL). W was measured to

the nearest 10 g on standardized scales by experienced staff. H was recorded to the nearest 0.1 cm in the standing position in 22 patients and in 12 patients in a recumbent position. If musculoskeletal deformities such as scoliosis or contractures were present, the heights of these children were corrected, with extremities measured one by one. Nutritional determinants were measured as skinfold thickness (triceps, subscapularis) using a standardized calliper. Two replicates of all measurement were taken and the mean value was used in the analysis. For triceps and subscapularis skinfold measurement, the values were related to corresponding data on American children. The W and H were also evaluated as weight for age (WFA), height for age (HFA), stature for age (sFA) and weight for stature (WFs). For each child, the H and W data were converted to relative HFA and relative WFA as percentages of the average H and W of Turkish children (8). sFA and WFs data were converted to relative data for age as percentages according to the Centers for Disease Control and Prevention, which were created by National Health Statistics, revised growth charts, published in 2000 (9).

Data Analysis

All the data were entered into a database for later analysis (SPSS, version 10.0 for Windows; SPSS Inc; Chicago, IL, USA). X^2 statistics were calculated to examine differences in frequencies for categorical variables. Demographic and clinical data were compared between two groups using independent-sample t test analysis for continuous variables and Mann-Whitney U for categorical variables and between three groups using analysis of variance (ANOVA) for continuous variables and Kruskal-Wallis for categoric variables. Pearson's correlation coefficients were used to examine the relationship between continuous variables, and Spearman's correlation coefficients were used to examine categorical variables. A 'P' value ≤0.05 was considered statistically significant.

Results

A total of 34 patients were included in this study. There were 22 males (64.7%) and 12 females (35.3%). The mean chronological age of patients was 73.29±29.3 (min: 20, max: 144) months. Sixteen (47.1%) children were spastic quadriplegic, 7 (20.6%) were spastic diplegic, and 5 children were spastic triplegic. Tables 1 and 2 summarize the demographic and clinical characteristics and anthropometric measurements of the 34 children who participated in this study. Of the study

Table 1. Demographic and clinical characteristics of our patients (n:34).

Age (months), mean±SD		73.29 ±29.3	
		n	%
Gender	Male	22	64.7
	Female	12	35.3
Topographic type	Quadriplegia	16	47.1
	Diplegia	7	20.6
	Triplegia	5	14.7
	Hemiplegia	3	8.8
	Mix	3	8.8
Ambulatory status	Wheelchair-bound	16	47.1
	HouseholdWWbraces	13	38.2
	Community walker	5	14.7
GMFCS	Level V	11	32.4
	Level IV	8	23.5
	Level III	10	29.4
	Level II	5	14.7

GMFCS: gross motor function classification system; HouseholdWWbraces: household walker with braces.

Table 2. Anthropometric measurements of our patient group (n=34).

	Mean±Standard deviation	min	max
Weight (kg)	16.85±5.7	10	36
Height (cm)	105.16±12.2	88	132
UAL (cm)	30.66±7.6	10.5	41.5
Triceps (mm)	13.52±5.5	6	28
Subscapularis (mm)	6.85±2.4	4	15

UAL: upper arm length.

group, none had a gastrostomy; 6 (17.6%) children had consumed nutritional supplements.

According to Ingstad and Sommerchild classification, 10 (29.4%) of 34 children were classified as severe type CP; 18 (55.5%) children were moderate and 6 (16,6%) were mild type CP. Ambulatory status was classified as follows: 16 (47.1%) children were wheelchair-bound, 13 (38.2%) walked with assistance (braces, canes, tripods) and 5 (14.7%) were independent walkers. According to GMFCS, 11 (32.4%) children were level V, 8 (23.5%) were level IV, and 15 (44.1%) were levels II and III.

The median W was <10th centile, and 10 (29.4%) were <3rd centile. The median H was <10th centile, and 15 (44.1%) were <3rd centile. Triceps and subscapularis skinfold measurement was <50th centile in 12 (35.3%) patients. The classification according to growth parameters is shown in Table 3.

Twenty-nine of 34 (85.3%) children had moderate to severe CP (GMFC III to V) according to gross motor classification. Slightly more than a quarter of all subjects had severe gross motor impairment (GMFC V), which was highly associated with the degree of growth measurement ($P < 0.007$). Of the total sample, highly positive correlations were found between anthropometric measurements and ambulatory status, whereby with higher levels of ambulation (community walker), the percentile of growth parameters increased ($r=0.389$, $p=0.004$). Additionally, nutritional status and skinfold measurements were highly related to ambulatory status but this relation did not reach statistical significance (respectively $P = 0.292$, $P = 0.117$). There was no relationship between chronological age and nutritional status and percentiles of growth determinants.

Discussion

In this study, we aimed to investigate the current growth and nutritional characteristics in a representative group of children with CP. The CP patients recruited for this study had poorer growth determinants and nutritional status than their peers. The growth determinants and nutritional classifications were used to describe the profile of children in this study. The profiles did not have enough potential to reflect grow charts of these children because the references used in the study were designed for the assessment of healthy Turkish children.

It is a well-known fact that a neurologically impaired child has impaired growth determinants because of cerebral, bulbar and spinal disorganization (5). In CP groups, these determinants were closely analyzed and discussed. These children are especially at risk because of oral, pharyngeal, or esophageal dysphagia besides the cerebral lesions (10,11). From our perspective, one of the important issues about growth determinants is their relationship with ambulation. In the literature, many potential benefits of nutrition have been emphasized briefly. According to Chandra et al. (12), nutrition improves immunity and affects the immune system. Shapiro et al. (13) demonstrated that improved nutrition makes children less irritable and less spastic.

Table 3. Growth and nutritional determinants of the patient group (n=34).

	>50th centile	25-50th centile	10-25th centile	3rd-10th centile	<3rd centile
Weight %	3 (8.8%)	5 (14.7%)	7 (20.6%)	9 (26.5%)	10 (29.4%)
Height %	3 (8.8%)	2 (5.9%)	4 (11.8%)	10 (29.4%)	15 (44.1%)
Stature for age %	4 (11.8%)	5 (14.7%)	4 (11.8%)	4 (11.8%)	17 (50%)
Weight for stature %	10 (29.4%)	5 (14.7%)	4 (11.8%)	2 (5.9%)	13 (38.2%)
Triceps %*	22 (64.7%)	12 (35.3%)			
Subscapularis %*	22 (64.7%)	12 (35.3%)			

* Skinfold thickness was analyzed for 50th percentiles.

The basic concept in nutrition is to provide adequate caloric intake to perform daily activities. Children with CP have been found to have higher levels of energy expenditure than healthy controls even when they were wheelchair-bound (14). On the other hand, Bandini et al. (15) determined reduced energy expenditure at rest and concluded that total energy reduction was related both to decreases in fat mass and to physical activity. Our results showed that the study group had adequate caloric intake. Hurvitz and colleagues (16) emphasized a different perspective on BMI and GMFCS in a group of 137 children with CP. They found a higher risk for being overweight among ambulatory children. In contrast to the findings of our study, they found the highest rate of overweight in the ambulatory children group (33%). Thus, they emphasized that the tendency to be overweight was associated with the low mitochondrial capacity and lower aerobic capacity accompanied by increased adiposity, not just the ambulation level.

In addition to the many issues about nutrition that have been investigated to date, perhaps one of the most important factors in children with CP is the production of adequate energy for ambulation. Azcue et al. (17) reported two types of resting energy expenditure in children with CP: normal energy expenditure and decreased energy expenditure. They hypothesized that the reduction was related with a possible alteration in catecholamine metabolism in the central nervous system. Bandini et al. (15) found nearly the same results. In their study on children with CP, the study group had decreased energy expenditure and decreased fat mass. They concluded that total energy reduction was highly related to both the decrease in fat mass and the level of physical activity in their study group. In our study, the triceps and subscapularis skinfold measurement was <50th centile in 12 (35.3%) children, which suggests that these children do not have adequate caloric intake to produce enough energy for daily activities, and 24 (64.7%) had adequate caloric intake. Most of the children in the less-calorie intake group had severe type CP and were wheelchair-bound.

In our study, ambulation was found to be highly related with nutrition and growth determinants. The patients with severe forms of CP had poorer growth determinants considering the normal nutritional status. This indicates that in this study sample, the severely affected group was also growth-deficient. In the study by Shapiro et al. (13), severe CP patients had a derogation of growth failure, especially linear growth failure. In our study, similar results were obtained. All the growth determinants were highly related with type and severity of CP. Quadriplegic non-ambulatory CP patients had the worst growth determinants and the lowest percentiles. This might have been associated with presence of several medical conditions concomitantly with severe CP, such as epilepsy, communication problems, oromotor dysfunction, endocrinologic problems, and less ground force effect because of immobilization. In recent literature, the relation between growth and these problems was discussed and it was reported that ground force effect and abnormal stress loads on the bone, decreased blood flow in the affected limb, and leptin deficiency are highly related with growth in children (18,19).

Moreover, the results in our patients revealed serious growth retardation in these CP patients. The detailed assessment of nutritional status and measurement of growth determinants are beneficial in the management of patients who are fighting against spasticity and other musculoskeletal problems.

In conclusion, ambulation level is highly related with growth determinants and vice versa. Physicians' awareness of this issue may yield great differences in achieving the desired stature and neurological well-being in these patients.

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