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A cross-sectional survey of growth and nutritional status in children with cerebral palsy in West China

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Running title: Growth, nutrition and cerebral palsy

Abstract

Objective: This study aims to describe the growth and nutritional status of children with cerebral palsy (2-18 year-old) in West China, and explore the correlation between the status and age, gender, gross and fine motor function. **Methods:** We performed a cross-sectional survey in children registered as cerebral palsy in China Disabled Persons' Federation (CDPF) branch in Chengdu. Growth (height and weight) and nutritional (Body mass index [BMI]) status were recorded. Gross Motor Function Classification System (GMFCS) and Manual Ability Classification System (MACS) were used to determine gross and fine motor function, respectively. The association between nutritional status and age, GMFCS and MACS was evaluated. **Results:** We enrolled 377 children (53.6% males), among whom, 160 (42.4%) were stunting, 48 (12.7%) underweight, 81 (21.5%) thin, and 70 (18.5%) overweight and obese. Thinness was the main nutritional problem in older patients (12-18 years), while overweight and obesity were the major issues in younger patients (2-12 years). Growth deviation and malnutrition were significantly more prevalent in patients with severe motor impairments. A significant negative correlation was found between nutritional status and age, GMFCS and MACS levels, and between growth and GMFCS and MACS levels. **Conclusion:** Growth deviation is common in cerebral palsy children. Malnutrition and overnutrition both exist in children with cerebral palsy. Characteristics at different age stages and motor functional levels should be taken into consideration in the management of growth and nutrition in this population.

Key Words: cerebral palsy; growth; nutritional status; gross motor function; fine motor function

Introduction

Cerebral palsy describes nonprogressive disturbances that occur in the developing fetal or infant brain and a group of permanent disorders in the development of movement and posture that causes limitations of activity. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, communication, and behavior, epilepsy, or secondary musculoskeletal problems (1). Cerebral palsy is one of the leading causes of childhood physical disability worldwide (2, 3). Its prevalence is 1.9‰ among 1-6 years old children in China (2), and varies between 2‰ and 4.4‰ in the developed countries (4). The variation of prevalence may result from inconsistent definitions and classifications or different methods of choosing the numerator and the corresponding population denominator (4).

Although motor function is the primary impairment in cerebral palsy, growth and nutritional disorders are also common. Children with cerebral palsy are reported to have unique growth patterns and various nutritional problems, ranging from malnutrition to overweight and obesity (5-9). These problems are more prominent with increasing severity of motor impairments (5, 9). Due to different study population and different assessing methods, the malnutrition rate in cerebral palsy patients is as high as 46-90% (10). Poor growth and malnutrition are related to more healthcare utilization, less societal participation (11) and worse motor function (6). On the other hand, in recent years, as obesity has become a global epidemic problem in general population, some researchers have found that children with cerebral palsy are also at high risk of being overweight and obese. A literature review of 38 articles reported that the prevalence of overweight and obesity in children with disabilities is almost twice as their non-disabled peers (12). Rogozinski et al. found that among ambulatory American children with cerebral palsy, the prevalence of obesity has increased from 7.7% to 16.5% over a decade (13). Hurvitz et al. found that 29.1% of children with cerebral palsy are overweight (95th BMI percentile) or at risk for being

overweight (85th to 95th BMI percentile), and their prevalence is higher than in the general population, whether in ambulatory or nonambulatory children(14). However, there are few studies concerning the growth and nutritional status in children with cerebral palsy or the association with gross and fine motor function in China.

The purposes of this study are: 1) to describe the growth (as determined by height and weight Z scores) and nutritional status (as determined by body mass index (BMI)) in 2-18 years old children with cerebral palsy in West China; 2) to investigate the relationship between growth or nutrition and age, gender, gross and fine motor function (as determined by Gross Motor Function Classification System (GMFCS) and Manual Ability Classification System (MACS)).

Subjects and Methods

Study design

This cross-sectional study was conducted by West China Second University Hospital of Sichuan University with help from China Disabled Persons' Federation (CDPF) Chengdu branch from February to April in 2013. The study was approved by both Ethics Committee of West China Second University Hospital of Sichuan University and the Institutional Review Board of each CDPF branch in Chengdu. A written informed consent was obtained from the parents or legal guardians.

The inclusion criteria were children resident in Chengdu, registered as cerebral palsy, and having received rehabilitation treatments either before or at the time of the study in the CDPF Chengdu branch. Information related to demographics, personal and family medical history, growth and development, diagnosis and rehabilitation intervention, etc. was collected using a self-made questionnaire, and the diagnosis of cerebral palsy was reevaluated by pediatric neurologists and rehabilitation physicians together according to the

definition proposed by Rosenbaum et al. (2). GMFCS and MACS were respectively used to assess gross and fine motor function status.

GMFCS and MACS

The GMFCS is an objective functional scale to assess the key functions of ambulation in cerebral palsy(1); it classifies children with cerebral palsy into five levels according to functional mobility or activity limitation (15). We employed the GMFCS (Chinese version) (16, 17) which has been proved to have good reliability and validity in Chinese children. The MACS is designed to reflect a child's typical manual performance; it classifies how well children aged 4-18 years with cerebral palsy use their hands when handling objects in daily activities (18). Likewise, we used the Chinese version of the MACS (19) which has been proved to be a valid and reliable measure of manual functions. The GMFCS was evaluated by two senior physiotherapists separately and MACS was assessed by two senior occupational therapists independently. If the evaluation result was inconsistent, the aforementioned experts would reevaluate the patient together and discuss a final conclusion. Children with GMFCS I–II or MACS I–II were categorized as minor motor function impairments, GMFCS III or MACS III as moderate impairments, and GMFCS IV–V or MACS IV–V as severe impairments.

Anthropometric measure

Anthropometric data for the weight and height were obtained via standard procedures and measuring instruments by trained staff. All measurements were obtained twice, and the average was used for analysis. Weight was recorded to the nearest 0.1 kg on a digital scale, with the child dressed in a thin set of clothes and without hats or shoes. If the child was unable to stand independently, we weighed the child with a caregiver. The child's weight

was found by subtracting the weight of the caregiver from the combined weight. Height was measured using a height scale to the nearest 0.5 cm while the child stood straight; if one could not stand because of muscle contracture, high tone or poor cooperation, the measurements were unreliable. The height was obtained using a flexible tape with the child lying on their back.

Data reduction

Initially, 578 children were screened. After we excluded children with traumatic, post encephalitic or progressive disorders, 421 were ascertained with cerebral palsy. Among them, 377 were aged between 2 to 18 years old and were eligible for the present study. Gender, age, family income, birth weight (BW) and gestational age (GA), height and weight, and GMFCS and MACS levels were documented. Children were grouped by age: 1) low age group, $2\text{yrs} \leq \text{age} < 6\text{yrs}$; 2) middle age group, $6\text{yrs} \leq \text{age} < 12\text{yrs}$; and 3) high age group, $12\text{yrs} \leq \text{age} \leq 18\text{yrs}$. Weight and height were converted to age and sex normalized Z scores according to reference data for healthy children (20, 21) while evaluating the growth deviation of cerebral palsy children. Height Z score below -2 was defined as stunting, while a Z score for weight below -2 was considered as underweight. Body mass index (BMI) was calculated [$\text{BMI} = \text{weight (kg)} / \text{height (m}^2\text{)}$] to assess the nutritional status. The percentile level of each child's raw BMI score, relative to age- and sex-specific norms, was obtained according to BMI growth curves for Chinese children aged 0-18 years (22). Children were classified into four categories based on their nutritional status: thin, normal, overweight, and obese. Since there were no unified BMI cut-offs for thinness among children younger than 6 years in China, these children were defined according to the criteria proposed by Cole et al. (23); and for children older than 6 years, the BMI cut-off for Chinese school-age children

aged 6-18 years (24) was applied. Overweight and obesity were defined according to the BMI cut-offs proposed by LI et al. (22).

Statistical analysis

Excel 2007 was adopted to establish a database, and all analyses were conducted using the Statistical Package for Social Sciences (SPSS) version 19. Mean and SD were calculated in continuous variables such as age, weight Z scores and height Z scores. Mann–Whitney Test was used to compare differences in growth and nutritious status between genders, and the Kruskal-Wallis test was used to analyze the differences of growth or nutrition among the three age groups, GMFCS levels and MACS levels. Number and frequency (%) were used to describe categorical variables, and the chi-square test was used to analyze differences in proportions among groups. Multiple comparisons between the groups were performed using a correct significant level α' . Spearman rank correlation analysis was used to examine the association between nutritional status and age, GMFCS and MACS. $P < 0.05$ was considered statistically significant. For multiple comparisons, significance was considered to be $P < \alpha'$ [$\alpha' = 0.05 / n * (n-1) / 2$, n =numbers of groups].

Results

Table 1 shows the patient characteristics by GMFCS and MACS levels. Overall, 377 cerebral palsy children aged 2 to 18yrs who were all home-living and feeding orally were included. GMFCS level was assessed in all patients, while MACS was evaluated in 326 patients aged 4 to 18yrs. In this study, 43.8% children were born with a low birth weight and 54.1% were premature. There were more males (53.6%) than females; the mean age was 7.9 ± 3.5 yrs and the middle age group accounted for more than half (50.7%). Age, gender, frequency of low birth weight and premature birth did not differ significantly in GMFCS or

MACS level, except that in children with GMFCS level III. The frequency of low birth weight was significantly higher in GMFCS level III than that in GMFCS I-II (55.2% versus 39.3%, $p=0.012$).

Growth deviation

As shown in Table 2, 160 (42.4%) children were stunting (height Z score below -2), and 48 (12.7%) were underweight (weight Z score below -2). There was no significant difference between different genders or age groups in the prevalence of stunting, but the incidence of underweight was significantly lower in males ($P=0.017$) and the middle age group ($P=0.009$). Children with GMFCS IV-V had 2 times higher prevalence of stunting than GMFCS I-II (61.9% versus 30.4%), and its prevalence of underweight was more than 4 times greater (24.8% versus 6.0%). In the MACS level, the prevalence of poor growth and weight gain increased as the manual ability impairments increased. MACS IV-V group had a significantly higher frequency of stunting than MACS I-II group ($P=0.002$), and the difference of prevalence of underweight between the most disabled and the most abled children was more than 3 times (26.2% versus 7.6%). Mean height and weight Z scores were significantly lower in children with GMFCS/MACS IV-V than GMFCS/MACS I-II. No significant differences of mean height and weight Z scores were found between two genders. Though mean growth deviation was smaller in low and middle age group compared with high age group, statistical difference was only found between two older age groups ($P=0.001$), in which high age group showed a significant weight growth deviation.

BMI percentiles

Figure 1 shows the distribution of BMI percentiles according to GMFCS level. Children with GMFCS IV-V were more commonly located at lower BMI percentiles than less

severely impaired children, with 23.9% located in the bottom 15th percentile, compared with 13.6% of GMFCS level III and 10.8% of GMFCS level I-II; While in the up 15th percentiles, the frequency for severe, moderate and minor gross impairments was 9.8%, 19.8% and 16.1%, respectively. Similar to GMFCS, the distribution of BMI percentiles by MACS level was not normal (Figure 2). Children with MACS IV-V showed an apparently negative skew distribution, with 27.4% in the bottom 15th percentiles and only 6% in the top 15th percentiles, when compared with MACS I-II 12.8% and 19.2% in the low and high 15th percentiles, respectively.

Nutritional status

No statistical difference was found in the nutritional status between the two genders (Mann-Whitney Test, $p=0.581$), therefore, males and females were combined for the afterwards analysis. Kruskal-Wallis Test showed that nutritional status in the three GMFCS level groups was significantly different ($p=0.009$). Multiple comparisons showed that children with GMFCS IV-V were significantly thinner, i.e. had poorer nutritional status than GMFCS I-II ($p=0.005$) and GMFCS III ($p=0.013$). Though the distribution of nutritional status in the three MACS level groups was significantly different (the chi-square test, $p=0.015$), no significant difference was found between the three groups using the Kruskal-Wallis Test. The high age group (12-18yrs) was significantly thinner when compared with low age group (2-6yrs, $p<0.001$) and middle age group (6-12yrs, $p=0.001$).

Normal

According to BMI, only 226 (59.9%) children with cerebral palsy were of normal weight (Table 3). Though the differences were not significant, children with GMFCS I-II or MACS I-II had the largest proportion of normal weight [109 (64.9%), 111 (64.9%)], while among

patients with GMFCS IV-V or MACS IV-V, the prevalence of normal weight was 59(52.2%) for GMFCS IV-V and 45(53.6%) for MACS IV-V.

Thinness

A total of 81(21.5%) cerebral palsy children were thin; no significant difference was found between males and females. Similar to the aforementioned results in the nutritional status examined by Kruskal-Wallis Test, patients in high age group (12-18yrs) showed significantly higher prevalence of thinness (38.5%) than the other two age groups. The prevalence of thinness increased as the severity of impaired gross or manual motor function increased, and children with the GMFCS/MACS IV-V presented significantly higher prevalence of thinness than GMFCS/MACS I-II($p=0.001$, $p=0.015$).

Overweight and obesity

Of all the children, 70 (18.5%) had a greater than normal weight. The number of overweight was 42(11.1%); the low age group showed a significantly higher prevalence of overweight compared with the high age group (17.2% versus 1.9%, $p=0.005$). A total of 28 (7.4%) children were considered obese in this population, and males had a higher prevalence of obesity than females (9.9% vs. 4.6%, $p=0.049$). When combined, overweight and obesity showed a higher prevalence in males (21.3%) than females (15.4%), but no significant difference was found ($p=0.145$). In contrast to a higher prevalence of underweight in the high age group, the incidence of obesity was significantly lower than those in the other two age groups (see Table 3). When combining obesity with overweight, the overall prevalence (1.9%) was also significantly lower in the high age group than in the low age group (25.4%, $p<0.001$) and middle age group (18.3%, $p=0.003$). The prevalence of overweight in the three GMFCS level groups was similar ($P>0.05$). Although children with MACS IV-V had an

obviously higher prevalence of overweight (14.3%) than those in the other two level groups, no significant difference was found. The prevalence of obesity or combination of obesity with overweight was higher in GMFCS/MACS I-II and III than that in GMFCS/MACS IV-V, but the difference was not significant.

Correlation test

Tables 4-6 show a series of correlation tests using Spearman rank analysis. A significant negative association was found between height Z score and GMFCS level ($r_s = -0.314$, $p < 0.001$) or MACS level ($r_s = -0.197$, $p < 0.001$), as well as a significant negative correlation between weight Z score and GMFCS level ($r_s = -0.304$, $p < 0.001$) or MACS level ($r_s = -0.22$, $p < 0.001$). As shown in tables 4 and 5, no correlation was found between age and height or weight Z score. When a significant negative correlation ($r_s = -0.229$, $p < 0.001$) was found between nutritional status and age, another negative correlation ($r_s = -0.306$, $p = 0.027$) was identified between age and nutritional status in the high age group (12-18yrs). A significant negative correlation between nutritional status and GMFCS level ($r_s = -0.129$, $p = 0.012$) and MACS level ($r_s = -0.113$, $p = 0.041$) was also found (see Table 6). Since the distribution of low birth weight was different in the three GMFCS level groups, a test between nutritional status and GMFCS levels further using partial correlation analysis with birth weight fixed was done. A significant negative correlation ($r = -0.120$, $p = 0.02$) was found.

Discussion

Our study showed that growth and nutritional disorders were common in children with cerebral palsy. Moreover, undernutrition and overnutrition were coexisting in this population. Height/weight Z score or nutritional status was negatively correlated with GMFCS/MACS

level, indicating that children with less severe motor function impairments tend to be taller and heavier in mild growth deviations, while those with severe motor impairments appear to be shorter, lighter and thinner with significantly retarded growth. Our current findings were in accordance with previous studies (8, 11, 25).

Nutritional factors were reported to play a substantial role in the development of poor growth and nutritional state (26). The nutritional factors can be summarized into three aspects: 1) inadequate energy intake secondary to various feeding problems results from poor oral motor and swallowing function (27), gastrointestinal disorders like gastroesophageal reflux disease (6), and lack of self-feeding skills (7) etc.; 2) extra energy expenditure due to spasticity or constant movements (28); and 3) nutrient losses, for instance, vomiting.

In the present study, we were not able to record the prevalence of feeding problems or the food or energy intake in cerebral palsy patients. According to previous studies, feeding and gastrointestinal problems are quite common in this population (27, 29) and are more marked in those with severe motor impairments (29). Benfer et al. reported that oropharyngeal dysphagia occurred in 85% of cerebral palsy children, with 70% in GMFCS I and 100% in GMFCS V (30). And according to Grammatikopoulou et al. (31), the caloric intake is inadequate in the majority of patients with cerebral palsy. Hillesund et al. (32) also reported that children with greater degrees of motor impairments have lower energy intake. These studies may explain the high prevalence of thinness (21.5%) and stunting (43.4%) in our study, especially among children with GMFCS IV-V, 32.7% were thin and 61.9% were stunted.

Currently, we found a significant negative correlation between nutritional status and MACS level; the more severe the manual impairment of the patient, the bigger the growth deviation was. In addition, children with MACS IV-V had significantly higher occurrence of

malnourishment than those with MACS I-II. Since all participants in the present study were orally feeding, our results indicate that impaired manual function may play a considerable role in the occurrence of growth retardation and malnutrition in cerebral palsy patients. Lacking of self-feeding skills can lead to inadequate energy intake. In addition, researchers have found that self-feeding skills are highly related to life expectancy (7). Therefore, both manual function and self-feeding abilities should be assessed early. Rehabilitation could then be performed early on to avoid adverse consequences in cerebral palsy patients.

The main consequence of malnutrition is growth failure. However, our study showed that the prevalence of stunting was almost 2 times higher than thinness in each age group or each GMFCS level group. If we exclude factors such as underlying inaccurate measurements owing to spasm or joint contractures, there may be other causes for the high prevalence of growth retardation in this study. For example, immobility and lack of weight bearing decreased mechanical stress on bones. The postnatal development of bones, according to Frost's mechanostat model, is driven by the mechanical forces which primarily arise from muscles of which the bones are subjected to (33). Lack of mechanical strains may lead to abnormal modeling of the bones thus may impair longitudinal bone growth. In addition, endocrine factors may also contribute to retarded growth in cerebral palsy patients. According to Kuperminc et al. (34), IGF -1 and GH concentrations are significantly lower in girls with cerebral palsy compared with typical children. Furthermore, the neurologic disease itself may adversely affect linear growth even in the absence of malnutrition.

It has been widely accepted that in the general population poor nutritional status may affect the respiratory, cardiac, muscular and immune systems, and may lead to some neurological problems such as diminishing cerebral growth, delaying cognitive development and inducing abnormal behavior, etc. (26). Except for the effects aforementioned, poor growth and malnutrition in cerebral palsy can cause other problems. Children with

malnutrition may have an increased risk of postoperative complications after surgery for scoliosis repair (35) owing to impaired wound healing and immunity. Diminished muscle strength may lead to further worsening of impaired motor function. According to Brooks et al. (36), children with cerebral palsy who have low weights are at increased risk of death. Children with GMFCS levels I and II and weights below the 5th percentile may have 2.2 times higher risk of death, while those with GMFCS levels III through V and weights below the 20th percentile are associated with a mortality hazard ratio of 1.5. Other investigators have found a significant correlation between poor nutritional status and increasing hospitalizations, doctor visits and decreasing participation in usual activities (11, 37). In contrast, improved nutritional status has been associated with improvements in some anthropometric findings and a decrease in number of infections (10) as well as progresses of gross motor function (6).

In our study, 18.5% of the children were above normal weight, with 11.1% of overweight and 7.4% of obesity, which is higher than that of typical children aged 3-18 yrs old in Chengdu in 2006, 9.5% overweight and 7.4% obese (38). Our results also showed a higher prevalence of overweight and obesity when compared with a study in Korea, 9.7% were overweight and 6.5% were obese during 2006 to 2008 (39). In contrast, our prevalence was lower than that reported in the US, in which the overall prevalence of overweight and obesity was 29.1% (14). The occurrence of overweight was higher than obesity, combining with a higher prevalence of overweight and obesity in lower age groups, indicating that the present population was in the early stages of epidemics of obesity. No significant difference was found between different GMFCS/MACS level groups and overweight and obesity. This is inconsistent with the study of Hurvitz et al. (14).

Overweight and obesity in children with cerebral palsy can present a barrier to healthcare givers. These patients can be difficult to lift or move thus may increase the

difficulty of nursing for the parents or caregivers, decrease social participation of children, or make it harder for rehabilitation therapist to perform training. And it has been demonstrated that general motor skill level of typical obese children is lower than their normal-weight and overweight peers (40), therefore in cerebral palsy patients with obesity, the motor function may be worse than non-obese ones and a poorer motor function may impair mobility further. Moreover, excess weight can cause the strain on joints and muscles which lead to fatigue and pain, and may impair mobility of the patient and quality of life (41). Since more children with cerebral palsy survive into adulthood (42), they may face the same health risks as general adult population, for example the increasing risk of cardiovascular diseases in obese patients.

This is the first study to explore the prevalence of growth and nutrition problems of cerebral palsy children in West China and to figure out their relations with age, gender and severity of motor impairment. Our findings are characterized as higher prevalence of malnutrition, over-nutrition and growth disorder in children with cerebral palsy. They may also indicate the overall status of cerebral palsy children in urban China.

However, our study has several limitations. Firstly, we only enrolled children who were registered in the CDPF branch of Chengdu. We could have missed some patients who did not register or refused to participate in the survey. Secondly, it's difficult to obtain accurate height in severe impaired children owing to the coexisted neuromuscular complications, such as joint contractures and muscle spasticity etc. Furthermore, the growth charts (20-24) applied in this study was based on general pediatric population, and may not be appropriate for children with cerebral palsy. Although there are some growth charts specified for cerebral palsy children (8, 10, 14), they are plotted based on American population therefore may not be suitable for Chinese children.

Conclusion

Growth and nutritional problems are common in children with cerebral palsy. Malnutrition and overnutrition both occur. Characteristics at different age stages and different gross and manual motor function status should be taken into consideration in the management of growth and nutrition in this population. Further study is needed to investigate the optimal weight or height for children with cerebral palsy to maintain health and well-being.

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Figure legends

Figure 1 Distribution of BMI percentiles for GMFCS level. BMI: body mass index; GMFCS: Gross Motor Function Classification System.

Figure 2 Distribution of BMI percentiles for MACS. BMI: body mass index; MACS: Manual Ability Classification System.

Table 1 Demographic characteristics grouped by GMFCS level and MACS level¹

	Number	Age group ² , %			Male, %	Low birth weight, %	Premature, %
		2-6/4-6	6-12	12-18			
GMFCS level							
I-II	168	35.7	50.0	14.3	54.2	39.3*	48.2
III	96	33.4	51.0	15.6	51.0	55.2	63.5
IV-V	113	37.2	51.3	11.5	54.9	40.7	54.9
Total	377	35.5	50.7	13.8	53.6	43.8	54.1
MACS level							
I-II	171	26.9	58.5	14.6	50.3	50.9	59.6
III	71	22.5	53.5	23.9	59.2	39.4	54.9
IV-V	84	25.0	63.1	11.9	51.2	38.1	47.6
Total	326	25.5	58.5	16.0	52.5	45.1	55.6

¹GMFCS: Gross Motor Function Classification System; MACS: Manual Ability Classification System; * compared with GMFCS III, P=0.012.

²Age groups for GMFCS level: 2-6 years, 6-12 years, 12-18 years. Age groups for MACS level: 4-6 years, 6-12 years, 12-18 years.

Table 2 Height and weight Z scores by gender, age group, GMFCS level and MACS level¹

Height Z score					Weight Z score			
Z<-2, n					Z<-2, n (%)			
(%)		P-value	Mean ± SD	P-value	(underweight)		Mean ± SD	P-value
(stunting)								
Gender		0.568		0.232				0.201
Male	83(41.1)		-1.60±1.85		18(8.9)	0.017	-0.66±1.64	
Female	77(44.0)		-1.85±1.76		30(17.1)		-0.88±1.30	
Age group, years		0.238		0.103		0.022		0.01
2-6	62(46.3)		-1.79±2.12		21(15.7)		-0.66±1.95	
6-12	73(38.2)		-1.57±1.53		16(8.4)	0.009▼	-0.68±1.22	0.001▼
12-18	25(48.1)		-2.03±1.88		11(21.2)		-1.28±0.86	
GMFCS level		<0.001		<0.001		<0.001		<0.001
I-II	51(30.4)	<0.001*	-1.21±1.82	<0.001*	10(6.0)	<0.001*	-0.40±1.63	<0.001*
III	39(40.6)	0.002*	-2.74±1.51	0.002*	10(10.4)	0.007*	-0.73±1.28	<0.001*
IV-V	70(61.9)		-2.46±1.80		28(24.8)		-1.31±1.28	
MACS level		0.006		0.001		<0.001		<0.001
I-II	62(36.3)	0.002#	-1.53±1.63	<0.001#	13(7.6)	<0.001#	-0.59±1.33	<0.001#
III	29(40.8)		-1.62±1.16	0.007#	7(9.9)	0.009#	-0.75±1.06	0.002#
IV-V	48(57.1)		-2.34±1.85		22(26.2)		-1.35±1.01	

¹GMFCS: Gross Motor Function Classification System; MACS: Manual Ability Classification System; SD, Standard deviation. ▼ compared with 12-18 years group. * compared with GMFCS IV-V. # compared with MACS IV-V.

Table 3 Nutritional status based on BMI in cerebral palsy children by gender, age, GMFCS level and MACS level¹

	Thinness		Normal		Overweight		Obesity	
	N (%)	P-value	N (%)	P-value	N (%)	P-value	N (%)	P-value
Gender		0.513		0.088		0.871		
Male	46(22.8)		113(55.9)		23(11.4)		20(9.9)	0.049 Δ
Female	35(20.0)		113(64.5)		19(10.9)		8(4.6)	
Age group		0.002		0.994		0.007		0.087
2-6	20(14.9)	<0.001▲	80(59.7)		23(17.2)	0.005▲	11(8.2)	0.036▲
6-12	41(21.5)	0.012▲	115(60.2)		18(9.4)		17(8.9)	0.027▲
12-18	20(38.5)		31(59.6)		1(1.9)		0	
GMFCS level		0.002		0.104		0.977		0.252
I-II	27(16.1)	0.001#	109(64.9)		19(11.3)		13(7.7)	
III	17(17.7)	0.013#	58(60.4)		11(11.5)		10(10.4)	
IV-V	37(32.7)		59(52.2)		12(10.6)		5(4.4)	
Total	81(21.5)		226(60.0)		42(11.1)		28(7.4)	
MACS level		0.051		0.184		0.093		0.049
I-II	30(17.5)	0.015*	111(64.9)		15(8.8)		15(8.8)	0.019*
III	15(21.1)		46(64.8)		3(4.2)		7(9.9)	0.024*
IV-V	26(31.0)		45(53.6)		12(14.3)		1(1.2)	
Total	71(21.8)		202(62.0)		30(9.2)		23(7.1)	

¹ BMI: body mass index; GMFCS: Gross Motor Function Classification System; MACS: Manual Ability Classification System. ▲ compared with 12-18 years group. # compared with GMFCS IV-V.

* compared with MACS IV-V.

Table 4 Correlation between height Z score and age, GMFCS and MACS level¹

	Spearman rho	P-value
Height Z score vs. Age	0.047	0.366
Height Z score vs. GMFCS level	-0.314	<0.001
Height Z score vs. MACS level	-0.197	<0.001

¹ GMFCS: Gross Motor Function Classification System; MACS: Manual Ability Classification System.

Table 5 Correlation between weight Z score and age, GMFCS and MACS level¹

	Spearman rho	P-value
Weight Z score vs. Age	-0.077	0.138
Weight Z score vs. GMFCS level	-0.304	<0.001
Weight Z score vs. MACS level	-0.220	<0.001

¹ GMFCS: Gross Motor Function Classification System; MACS: Manual Ability Classification System.

Table 6 Correlation between nutritional status and age, GMFCS and MACS level¹

	Spearman rho	P-value
Nutritional status vs. Age	-0.229	<0.001
Nutritional status vs. GMFCS level	-0.129	0.012
Nutritional status vs. MACS level	-0.113	0.041

¹ GMFCS: Gross Motor Function Classification System; MACS: Manual Ability Classification System.