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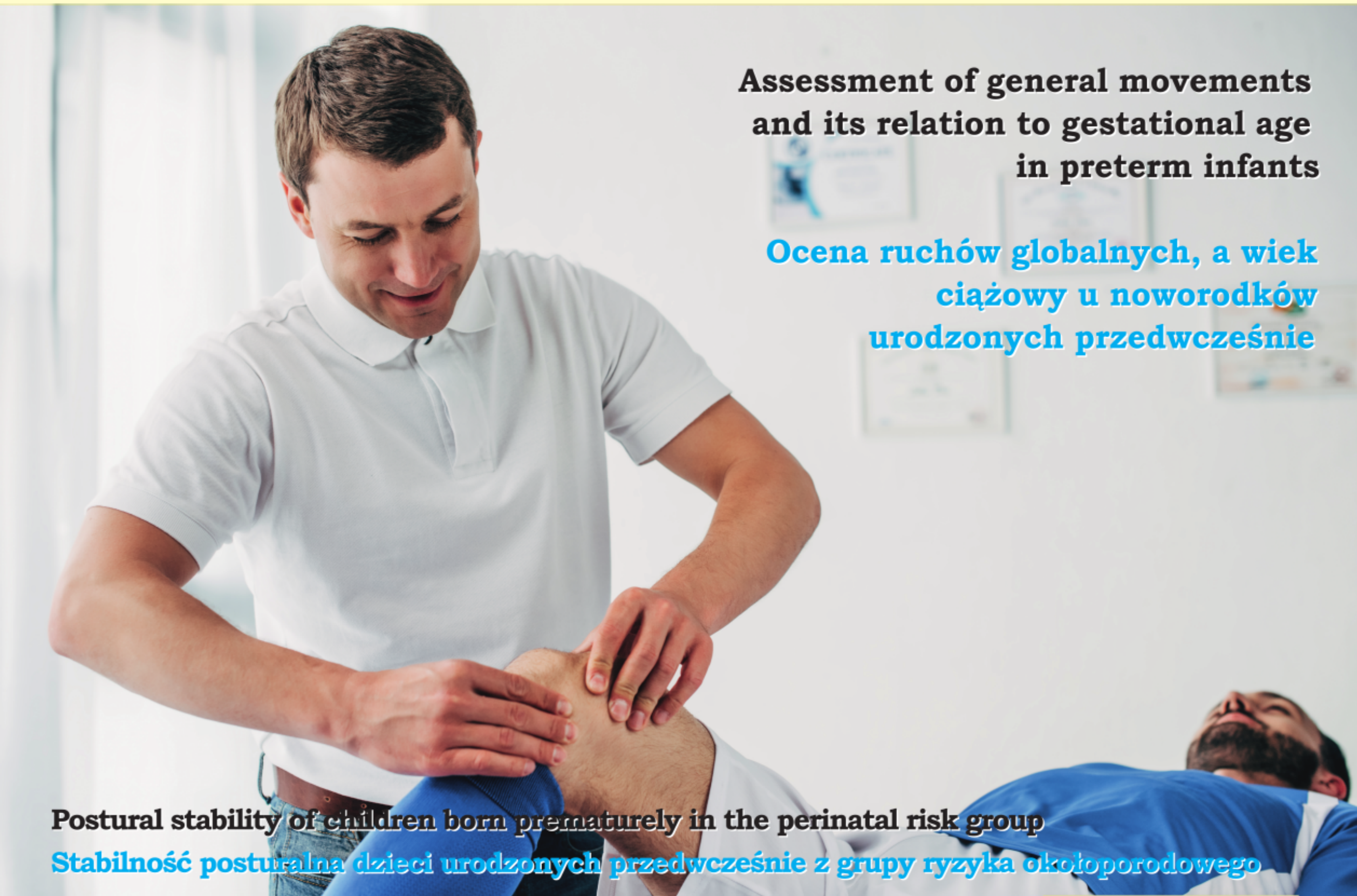

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Body composition and spasticity in children with bilateral cerebral palsy

Skład masy ciała a spastyczność dzieci z obustronnym niedowładem kończyn dolnych

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Abstract
Objective. The objective of this study was to identify the correlation between body composition of children with cerebral palsy and the degree of spasticity in the muscles of the lower limbs.
Material and methods. The study included a group of 59 independently walking children aged 8 to 16 with spastic diplegia. The control group included 59 children without central movement disorders - students at Primary School No. 25 in Sosnowiec. The research included: 1) assessment of body composition and its components using the TANITA MC-780 S MA scale; 2) assessment of the degree of spasticity according to the modified Ashworth scale; 3) calculations of BMI indices in accordance with the recommendations of the World Health Organization (WHO) and BMI OLAF developed by the Children's Memorial Health Institute in Warsaw.
Results. The most severe spasticity, both in the right and left lower limbs, was observed in the extensors of the ankle joint. In turn, the mildest spasticity was observed in the group of flexors of the knee joint of the right and left lower limbs. The greater the degree of spasticity in the muscles of the lower limbs, the greater the deficit in fat-free mass and muscle mass in the lower limbs.
Conclusions. Children with CP have deficits in terms of muscle mass. The deficit of muscle tissue depends on the degree of spasticity of the proximal muscle groups of the lower limbs.

Key words:
body composition, spasticity, cerebral palsy

Streszczenie
Cel. Celem niniejszego opracowania było rozpoznanie zależności pomiędzy składem masy ciała dzieci z mózgowym porażeniem dziecięcym a stopniem spastyczności mięśni kończyn dolnych.
Materiał i metoda. Badaniem objęto 59-osobową grupę samodzielnie chodzących dzieci w wieku od 8 do 16 lat z obustronnym spastycznym niedowładem kończyn dolnych. Do grupy kontrolnej włączono 59 dzieci bez ośrodkowych zaburzeń ruchowych – uczniów Szkoły Podstawowej nr 25 w Sosnowcu. Badania obejmowały: 1) ocenę składu masy ciała oraz jego komponentów przy użyciu wagi TANITA MC-780 S MA; 2) ocenę stopnia spastyczności wg zmodyfikowanej skali Ashwortha; 3) obliczenia wskaźników BMI zgodnie z rekomendacją World Health Organization (WHO) oraz BMI OLAF opracowanych przez Instytut „Pomnik – Centrum Zdrowia Dziecka" w Warszawie.
Wyniki. Największe nasilenie spastyczności, zarówno w prawej, jak i lewej kończynie dolnej, występowało w obrębie grupy mięśni prostowników stawu skokowego. Z kolei najmniejsze nasilenie spastyczności zaobserwowano w grupie mięśni zginaczy stawu kolanowego prawej i lewej kończyny dolnej. Im większy był stopień spastyczności mięśni kończyn dolnych, tym większy był deficyt masy beztłuszczowej i masy mięśni kończyn dolnych.
Wnioski. u dzieci z MPD występują deficyty w zakresie masy tkanki mięśniowej. Deficyt tkanki mięśniowej zależy od stopnia spastyczności proksymalnych grup mięśniowych kończyn dolnych.

Słowa kluczowe:
skład masy ciała, spastyczność, mózgowe porażenie dziecięce

Introduction

Cerebral palsy (CP) covers such a wide range of clinical symptoms and functional disorders that it entails the need for its further classification. The commonly used CP classifications adopted so far were based mainly on the criterion of the distribution of limb paresis (division according to Ingram from 1955) [1], which over time were supplemented with the predominant character of muscle tension and motor disorders (division according to Hagberg from 1984). The division according to the topography of paresis distinguishes the following forms of CP: diplegia, hemiplegia, bilateral hemiplegia and mixed forms [2].

Diplegia results from damage to the structure of the so-called upper motor neuron during its early development. Damage to the cerebrospinal tract in the vicinity of the lateral ventricles of the brain causes that the fibres of the cerebrospinal tract governing the function of the lower limbs are more damaged than the fibres of the cerebrospinal tract governing the function of the upper limbs. Approximately 70% of patients with diplegia have spastic muscle tension dysfunctions, which is why this form of CP is called spastic diplegia (diplegia spastica). Most children with this form of CP master the ability to walk independently, most often between the age of 2 and 4. The severity of changes in the lower limbs may vary from mild to severe spasticity. According to Pandyan [3], "spasticity is a polyethiological phenomenon and may appear as an image of damage to the upper motor neuron not only in CP". It is defined as impaired sensorimotor control of muscle tone, manifested by periodic or sustained involuntary increased muscle activity (according to Pandyan) [3]. As a result of spasticity, muscle contraction is excessive, inadequate to the stimulus, which under normal conditions would not cause any reaction. What is typical for this condition is that impaired motor control is more pronounced in the distal than in the proximal segments of the limbs, and therefore the distal muscles are more prone to the effects of spasticity. The basic clinical symptoms of spasticity include: 1) excessive tendon reflexes; 2) increased resistance during passive movement, especially at high velocity; 3) limited range of motion (especially distal limb joints), 4) decreased muscle strength and muscle contractures, but also impairment of natural muscle growth and increased energy consumption resulting from the activation of more muscles [4-6].

Limited range of motion, nutritional disorders of the articular cartilage, muscle contractures and venous blood stagnation lead to increased joint stiffness and loss of function of these joints, the consequence of which is, among others, difficult performance of everyday activities. In turn, reduced balance and sensorimotor disorders also contribute to the formation of an incorrect posture pattern in these children, which will then disturb the muscle tone and affect the lack of synergy. Disturbances in maintaining balance and independent body posture cause that the system of children with CP is not fully loaded, which will disturb the achievement of the correct peak bone mass and lead to muscle mass deficiencies in these children [7, 8].

Objective

The objective of this study was to identify the correlation between body composition and its individual components and the degree of spasticity in the muscles of the lower limbs in children with diplegia. An additional objective of the study was to recognize the differences between body composition and its individual components in children with CP with diplegia and their healthy peers.

Material and methods

The study is part of a broader research program aimed at identifying quantitative differences in the individual components of body composition in children with various forms of CP (spastic hemiplegia and spastic diplegia) and the correlation between their body composition, the level of spasticity and the functional level according to the GMFCS of these children.
The research project received a positive opinion of the Bioethical Committee of the Medical University of Silesia in Katowice (KNW/0022/KB1/89/15).

Material

The study involved a group of 59 children with CP with spastic diplegia with different intensified symptoms of spasticity in the lower limbs (study group - SG). The inclusion criteria were as follows: 1) ability to independently maintain a standing position; 2) diplegia diagnosis; 3) informed consent of the child's parents or legal guardians to participate in the study. The exclusion criteria were: 1) other acute and chronic diseases apart from CP; 2) inability to understand and follow instructions. The control group (CG) included 59 counterparties (in terms of gender and age), who were students at Primary School No. 25 in Sosnowiec, without central movement disorders based on the results of medical examinations contained in their medical record books. The characteristics of the participants in both groups are presented in Table 1.

Table 1. Demographic and anthropometric factors in the study group (SG) and the control group (CG)

Parameter	SG (n = 59)	CG (n = 59)	Statistical test, significance level p
Girls, n (%)	26 (43)	24 (42)	χ^2 = 2,75; p = 0,09
Boys, n (%)	33 (57)	35 (58)	
Age [years], mean (SD)	11.47 (2.25)	11.39 (2.34)	U = 1701; p = 0.83
Weight [kg], mean (SD)	34.28 (11.77)	52.57 (10.34)	U = 423; p = 0.00
Height [cm] / mean (SD)	142.89 (13.65)	150.89 (12.94)	U = 1191; p = 0.00
GMFCS			
Level 1, n (%)	13 (22.03)	–	–
Level 2, n (%)	46 (77.97)	–	–

Methods

Before commencing the examination of body composition in each child, in both groups – study group and control group – body height was measured using a TANITA height measuring device with an accuracy of 0.1 cm. Body composition was then measured using a TANITA MC-780 S MA scales (TANITA Corporation, 1-14-2 Maeno-cho, Itabashi-ku, Tokyo 174-8630 Japan). During the examination, the patients were stripped down to their underwear, stood upright on the scale in a free standing position. All examinations were carried out about midday, after a light breakfast at around 9:00 am, and before lunch, i.e. between 11:00 and 13:00. The following parameters of body composition were used for statistical analysis [9]: BMR (kJ) – basic metabolic rate, FM% – percentage of fat mass, FM (kg) – fat mass, FFM (kg) – fat-free mass, FFM % – percentage of fat-free mass, FFMI (kg/m²) – fat-free mass index, TBW (kg) – total body water, TBW% – percentage of total body water, PMM (kg) – predicted muscle mass, PMM% – percentage of predicted muscle mass, SMM (kg) – skeletal muscle mass, SMM% – percentage of skeletal muscle mass, Imp (Ohm) – impedance, SMI (kg/m²) – skeletal muscle index and body composition parameters for the right and left lower limbs: RLFM (%), percentage of fat mass in the right and left lower limbs; RLFM (kg), fat mass in the right and left lower limbs; RLFFM (kg), fat-free mass in the right and left lower limbs; RLFFM (%), percentage of fat-free mass in the right and left lower limbs; RLPMM (kg), muscle mass in the right and left lower limbs; RLPMM (%), percentage of muscle mass in the right and left lower limbs; RLIMP (Ohm), impedance in the right and left lower limbs.

The following body mass indices were used: BMI – calculated by Tanita scales, BMI percentile and BMI z-score, calculated by the AntroPlus program (recommendation of the World Health Organization (WHO) [10] and BMI OLAF, percentile grids developed by the Children's Memorial Health Institute [11]. Additionally, the BMI percentile was classified: 1 – body weight deficiency (<25 c), 2 – normal (25–75 c), 3 – overweight and obesity (>75 c).

In the next stage, the degree of lower limb muscle spasticity was assessed in children in the study group. The degree of spasticity was assessed using the six-point Ashworth scale modified by Bohannon and Smith [12]. The following muscle groups were rated on a scale from 0 to 4: 1) hip flexors (HF); 2) hip adductors (HA); 3) knee flexors (KF); 4) knee extensors (KE); 5) ankle extensors (AE), where 0 meant normal muscle tone, 1 – a slight increase in muscle tone, felt as resistance at the end of flexion and extension, +1 – a slight increase in muscle tone manifested by resistance for less than half of the range of motion, 2 – a clear increase in muscle tone felt as resistance throughout the entire range of motion, 3 – a significant increase in muscle tone, clearly difficult passive movements and 4 – flexion or extension contracture. The mean value of the degree of spasticity was also calculated for the right and left lower limbs and for both lower limbs.

Statistical analysis

In order to check the normality of the distribution of the measured parameters, the Shapiro-Wilk test as well as skewness and kurtosis test for the examined variables were used. The basic descriptive statistics were then calculated. The data is presented in tables in the form of mean values and standard deviation or median and lower and upper quartile, as well as minimum and maximum values.

The Mann-Whitney U test was used to compare body composition (parametric variables) in the study group and the control group, while the chi-square test was used to compare non-parametric variables such as gender and BMI classification. In all analyses, the significance level was $\alpha = 0.05$.

Pearson's correlation analyses were performed to assess the correlation between body composition of children with CP and the level of lower limb spasticity. Only the correlation coefficients for which the value of α was 0.05 were considered statistically significant. Correlation coefficients were interpreted according to Altman's recommendations: Rs <0.2, weak; 0.21-0.4, low; 0.41–0.6, moderate; 0.61–0.8, high; and 0.81–1, very high. The analyses were performed using the STATISTICA 13 software.

Results

The values of the general indices of body composition of the study group and the control group are presented in Table 2.

Table 2. General indices of body composition and the division of the patients due to different classifications of BMI in the study group and the control group

Parametr/Parameter	SG (n = 59)	CG (n = 59)	U; p-value
BMI [kg/m²], mean (SD)	16.49 (3.47)	22.88 (1.51)	U = 228; p = 0.00
BMI percentile, mean (SD)	33.30 (33.96)	67.91 (32.91)	U = 809; p = 0.00
Z-score BMI, mean (SD)	−1.20 (1.61)	0.79 (1.31)	U = 614; p = 0.00
OLAF BMI, mean (SD)	19.40 (33.35)	63.56 (29.02)	U = 541; p = 0.00
BMI percentile classification:			
1	27 (45,76)	11 (18,64)	
2	21 (35,59)	12 (20,34)	χ^2 = 22,49; p = 0,00
3	11 (18,64)	36 (61,02)	

U – test Manna–Whitneya, p – poziom istotności statystycznej
U – Mann-Whitney test, p – statistical significance level

In the study group, BMI values ranged from 11.83 to 24.06, where the mean was 16.49 ± 3.47 kg/m², which indicates underweight in these children. On the other hand, the BMI percentile value for children from the study group was 33.30 ± 33.96 with a wide range of values 0.10–97.10. On the other hand, in children in the control group, BMI values were higher and ranged from 19.60 to 27.30, where the mean was 22.88 ± 1.51 kg/m², which indicates the normal weight in these children. Then, the BMI percentile value in children in the study group was 67.91 ± 32.91 with an even greater range of values from 0.10–97.90 than in the study group.

The analysis of the results also showed that the children in the study group had significantly lower values of BMI (kg/m²), BMI percentile, BMI z-score and OLAF compared to children from the control group (Table 2).

When analysing the individual components of body composition among the patients from the study group, it was noted that FM% in the study group ranged from 3.00 to 42.50 (19.42 ± 8.37%). In turn, FFM% was in the range from 57.50 to 97.00 (80.58 ± 8.37%), and TBW% was in the range from 0.29 to 0.80, with the mean of 0.55 ± 7.96%. PMM% among children from the study group ranged from 57.47 to 100.00 (75.73 ± 9.33%). On the other hand, SMM% in the study group ranged from 28.70 to 54.90, and the mean was 43.76 ± 7.39%. In the control group, FM% was higher than in the study group and ranged from 13.10 to 39.80 (25.03 ± 5.79%). Then FFM% was in the range from 60.20 to 86.90 (74.51 ± 5.79%), and TBW% was in the range from 0.38 to 0.58, with the mean of 0.49 ± 4.88%. In children in the control group, PMM% ranged from 48.85 to 71.06 (61.12 ± 6.08%).

A comparative analysis of the individual components of body composition showed that there was a variation in the parameters of body composition between the study group and the control group (Table 3). In the study group, as compared to the control group, statistically significantly lower values were recorded for the following components of body composition, i.e.: BMR (kJ), FM%, FM (kg), FFM (kg), FFMI (kg/m²), TBW (kg), PMM (kg), SMM (kg), Imp (Ohm), and also for SMI (kg/m²) – Table 3. On the other hand, statistically significantly lower values of FFM%, TBW% and PMM% (Table 3) were observed in the control group compared to the study group.

The analysis of individual body components, taking into account their distribution within the lower limbs, showed that mean FM% in the left lower limb in the study group was 30.99 ± 6.23, and in the right lower limb it was 30.41 ± 7.24. Then mean FM% in the left lower limb in this group was 69.01 ± 6.23, and in the right lower limb it was 69.59 ± 7.24. On the other hand, in the same group, mean PMM% in the left lower limb was 63.23 ± 13.61, and in the right lower limb, the mean was 64.89 ± 14.60.

In the control group, mean FM% in the left lower limb was 32.98 (± 5.45), and in the right lower limb it was 33.36 (± 5.37). Then, mean FFM% in the left lower limb was 67.02 (± 5.45) and in the right lower limb it was 66.64 (± 5.37). Mean PMM% in the left lower limb in the control group was 64.10 (± 4.56), and in the right lower limb it was 63.82 (± 4.80).

The study group and the control group differed significantly in RLFM (kg), RLFFM (kg), RLPMM (kg) and RLIMP (Ohm) in the left lower limb. RLFM (kg) in the study group was significantly lower compared to the control group. The same was shown for RLFFM (kg) and RLPMM (kg), which were also statistically significantly lower in the children from the study group (Table 4).

Similarly, in the case of the right lower limb, all measured parameters differed significantly between the study group

Table 3. Values of individual components of body composition in the study group and the control group

Parameter	SG		CG		U	p
	Me	Q1–Q3	Me	Q1–Q3		
BMR[kJ]	4994.80	4100.60–5208.40	5807.10	5551.10–6167.20	179	0.00*
FM%	18.70	13.70–23.20	24.60	21.80–28.90	951	0.00*
FM [kg]	6.00	3.70–9.70	13.20	9.30–16.50	514	0.00*
FFM [kg]	26.00	20.10–29.30	33.20	29.90–38.10	790	0.00*
FFM%	81.30	76.80–86.30	75.40	71.10–78.20	951	0.00*
FFMI [kg/m²]	12.77	11.51–14.18	15.14	13.96–15,61	683	0.00*
TBW [kg]	19.00	14.10–22.00	24.30	21.90–29.00	777	0.00*
TBW%	0.56	0.52–0.62	0.51	0.47–0.52	733	0.00*
PMM [kg]	24.60	19.10–27.60	31.40	28.30–36.20	825	0.00*
PMM%	77.78	70.23–81.69	62.07	56.10–66.23	354	0.00*
SMM [kg]	15.00	13.10–16.00	20.50	17.30–23.80	357	0.00*
SMM%	44.20	36.90–50.20	43.50	38.20–55.80	1642	0.60
Imp [Ohm]	718.20	700.00–755.43	725.66	645.58–782.00	1665	0.69
SMI [kg/m²]	4.49	3.99–5.30	5.56	5.40–5.90	406	0.00*

*Me – median; Q1–Q3 – lower and upper quartile; U, Mann-Whitney test; *statistical significance (P < 0.05); BMR (kJ) – basic metabolic rate, FM% – percentage of fat mass, FM (kg) – fat mass, FFM (kg) – fat-free mass, FFM% – percentage of fat-free mass, FFMI (kg/m²) – fat-free mass index, TBW (kg) – total body water, TBW% – percentage of total body water, PMM (kg) – muscle mass, PMM% – percentage of muscle mass, SMM (kg) – skeletal muscle mass, SMM% – percentage of skeletal muscle mass, Imp (Ohm) – impedance, SMI (kg/m²) – skeletal muscle index*

Table 4. Values of body composition within the lower right and left limb and their intergroup differentiation

Parameter	Lower right limb				Lower left limb				LL Dex.		LL Sin.	
	SG		GK / CG		SG		CG		SG vs CG		SG vs CG	
	Me	Q1–Q3	Me	Q1–Q3	Me	Q1–Q3	Me	Q1–Q3	U	p	U	p
RLFM [%]	31.40	24.80–34.40	34.00	30.50–35.70	33.60	26.60–36.00	32.60	29.00–35.20	1238	0.01	1583	0.40
RLFM [kg]	1.40	0.90–2.20	2.60	2.10–3.50	1.50	0.80–2.40	2.50	2.10–3.40	722	0.00	810	0.00
RLFFM [kg]	3.80	2.60–4.60	5.50	4.60–6.40	3.50	2.50–4.30	5.30	4.50–6.30	634	0.00	621	0.00
RLFFM [%]	68.60	65.60–75.20	66.00	64.30–69.50	66.40	64.00–73.40	67.40	64.80–71.00	1238	0.01	1583	0.40
RLPMM [kg]	3.30	2.20–4.40	5.20	4.40–6.10	3.30	2.30–4.00	5.00	4.30–6.00	583	0.00	446	0.00
RLPMM [%]	64.58	62.50–73.47	62.39	60.87–65.31	61.19	59.70–71.43	64.00	61.86–67.09	1346	0.03	1638	0.58
RLIMP [Ohm]	374.40	323.90–390.20	300.00	289.90–324.90	379.10	330.40–399.10	288.70	259.80–322.60	817	0.00	433	0.00

Me – median, Q1–Q3 – lower and upper quartile, U – Mann-Whitney test, p – statistical significance level, RLFM(%) – percentage of fat mass in the lower limb, RLFM (kg) – fat mass in the lower limb, RLFFM (%) – percentage of fat-free mass in the lower limb, RLPMM (kg) – muscle mass in the lower limb, RLPMM (%) – percentage of muscle mass in the lower limb, RLIMP (Ohm) – impedance in the lower limb.

and the control group. RLFM% for the right lower limb was significantly higher in children in the control group. However, RLFFM%, RLPMM% and RLIMP (Ohm) in the right lower limb were statistically significantly higher among children from the study group (Table 4).

The analysis of the severity of spasticity within the muscles of the lower limbs (right and left) showed that the highest value of the degree of spasticity was found within AS in both lower limbs (Table 5). On the other hand, the lowest spasticity was observed within KF of both lower limbs (Table 5). The mean value of spasticity for the right and left limbs changed to a similar extent, for the right limb it was 1.75 ± 0.58, and for the left limb it was 1.77 ± 0.50 (Table 5). In turn, the mean value of spasticity for both lower limbs was 1.76 ± 0.52.

Table 5. Degree of spasticity of the muscles of the lower right and left limbs according to the Ashworth scale in the study group

Parameter	Lower right limb					Lower left limb				
	M	Me	SD	Min	Max	M	Me	SD	Min	Max
HF	1.45	1.00	0.83	0.00	3.00	1.53	1.00	0.80	0.00	3.00
KE	1.97	2.00	0.54	1.00	3.00	1.97	2.00	0.50	1.50	3.00
HA	1.58	1.50	0.64	1.00	3.00	1.61	1.50	0.61	1.00	3.00
KF	1.24	1.00	1.01	0.00	3.00	1.35	1.00	0.94	0.00	3.00
AE	2.53	3.00	0.56	1.00	3.00	2.42	2.00	0.50	2.00	3.00
Average spasticity	1.75	1.50	0.58	0.90	3.00	1.77	1.70	0.50	0.90	3.00

M – mean, Me – median, SD – standard deviation, Min – minimum value, Max – maximum value, HF – hip flexors; KE – knee extensors; HA – hip adductors; KF – knee flexors; AE – ankle extensors

In the next step of the analysis, it was checked whether there was a correlation between body composition of the right and left lower limbs and the average degree of spasticity of the muscles of the right and left lower limbs. Here, a low negative correlation was observed between RLFM (kg) in the lower limbs (r = −0.30), RLPMM (kg) in the lower limbs (r = −0.38) and lower limb spasticity. Additionally, a moderate negative correlation was also observed between RLFFM (kg) (r = −0.41) and lower limb spasticity. These results show that the greater the degree of spasticity in the muscles of the lower limbs, the greater the RLFM (kg), RLFFM (kg) and RLPMM (kg) deficits in the lower limbs (Table 6).

The highest negative high correlation (r = −0.63) was noted between SMI (kg/m²) and the mean degree of lower limb spasticity, which proves that the greater the degree of spasticity, the lower the SMI (kg/m²). A moderate negative correlation between PMM% (r = −0.40), TBW% (r = −0.59) and the mean degree of spasticity of the lower limbs indicates a reciprocal influence of these factors among children with CP (Table 6).

Table 6. Pearson's correlation values between individual components of body composition and the mean degree of spasticity of the muscles of the lower limbs in the study group

Parameter	r	P
BMI [kg/m²]	−0.33	0.01*
BMI percentyl	−0.36	0.01*
BMI z–score	−0.33	0.01*
OLAF BMI	−0.33	0.01*
BMR [kJ]	0.15	0.25
FM%	−0.23	0.08
FFM%	−0.19	0.14
TBW%	−0.59	0.00*
PMM%	−0.40	0.00*
SMM%	−0.32	0.01*
Imp [Ohm]	−0.39	0.00*
SMI [kg/m²]	−0.63	0.00*
RLFM [%]	−0.06	0.50
RLFM [kg]	−0.30	0.00*
RLFFM [kg]	−0.41	0.00*
RLFFM [%]	0.06	0.50
RLPMM [kg]	−0.38	0.00*
RLPMM [%]	0.10	0.29
RLIMP [Ohm]	0.29	0.00*

$p < 0.05$; BMI (kg/m²) – body mass index, BMI percentile classification 1, < 25 c; 2, 25–75 c; 3, > 75 c; BMR (kJ), basic metabolic rate; FM%, percentage of fat mass; FFM%, percentage of free-fat mass; TBW%, total body water; PMM%, percentage of muscle mass; SMM%, percentage of skeletal mass; Imp (Ohm), impedance; SMI (kg/m²), skeletal mass index; RLFM (%), percentage of fat mass in the right and left lower limbs; RLFM (kg fat mass in the right and left lower limbs; RLFFM (kg), fat-free mass in the right and left lower limbs; RLFFM (%), percentage of fat-free mass in the right and left lower limbs; RLPMM (kg), muscle mass in the right and left lower limbs; RLPMM (%), percentage of muscle mass in the right and left lower limbs; RLIMP (Ohm), impedance in the right and left lower limbs.

Discussion

The objective of this study was, among others, to identify differences in body composition and its individual components between children with CP with diplegia and their healthy peers. The results of this study show that children with CP had significantly lower body composition parameters than their healthy peers. The comparative analysis carried out showed that the study group was significantly different from the control group, and children with CP presented significantly lower values for most components of body composition, such as: basic metabolic rate, percentage of fat mass, fat-free mass index, skeletal muscle index and muscle mass index. Similar re-

sults were published by Ane-Kristine Finbrateni et al., who showed that children with CP had problems with growth inhibition, which resulted in them being shorter and having reduced body weight compared to their healthy peers [12].
The results of our study showed that children with CP had statistically significantly lower values of BMI (kg/m²), BMI z-score and BMI percentile compared to the control group, as well as lower body weight and were statistically significantly shorter. Another study also confirmed that children with CP were shorter, had lower body mass, BMI and BMI percentiles compared to healthy children. Significant growth retardation was most evident in children with diplegia [13]. These earlier studies were confirmed by the results of our study, where similarly the values of both body weight, BMI, and BMI percentile were significantly lower in the study group. So were the results of the parameters of fat mass, fat-free mass and total body water in children with CP [14].
The main objective of this study, however, was to identify the correlation between body composition and its individual components and the degree of spasticity in the muscles of the lower limbs in children with diplegia.
On the basis of the obtained results, a correlation was found between higher muscle tone and a decrease in body composition parameters. An interesting finding in this study was that children with diplegia who had a higher degree of spasticity in the muscles of the lower limbs had significantly lower percentages of fat mass, fat-free mass, and muscle mass in the lower limbs. This finding was confirmed by the results of other studies, which also showed lower parameters of individual components of body composition [15]. Eating disorders constitute another important aspect of body composition disorders in children with CP [16]. In the latest study conducted by Pascoe et al., the authors pay special attention to the problems related to the methods and nutritional possibilities of children with CP, which translates directly into their disorders in providing the body with the necessary nutrients [17]. Consequently, in diseases involving excessive muscle tone, the energy demand is also increased [18, 19]. Therefore, as a result of the above disorders, malnutrition and growth retardation may occur, which will directly result in problems with movement and undertaking physical activity. The results of subsequent studies show that children with CP are also characterized by lower muscle strength compared to healthy children [20]. Subsequent studies concerned all muscle groups in the lower limbs, muscle strength was positively correlated with the standing and walking function on the gross motor function assessment scale. Training to increase muscle strength will have a positive effect on the skeleton and muscle deficiency. Such unfavourable changes observed in body composition later predispose children with CP to the occurrence of metabolic disorders and further progressive changes in their body composition [21, 22]. There are also findings related to an increased need for energy intake proportional to the increased muscle tone. This results in the reduction of all components of body mass, including muscle mass, which has been shown in our

observations. And reducing muscle tone (according to the modified Ashworth Scale) and reducing the energy requirement will reduce the risk of malnutrition [23].

Summarizing the results of this study, it should be emphasized that although several previous studies have shown that children with CP have lower body composition parameters compared to their healthy peers, only the results of our study showed statistically significant differences in individual components of body composition within the lower limbs. The results obtained here showed that in children with diplegia, there are inversely proportional correlations between the general index of muscle mass, as well as the mass of skeletal muscles of the lower limbs and the degree of spasticity of these muscles. Despite the promising results of this study, more research is needed in children with other forms of CP in larger research populations.

Conclusions

1. The use of the bioelectric impedance method allows to identify quantitative and qualitative differences in body composition of the lower limbs in children with CP compared to their healthy peers.
2. Children with CP have deficits in the ratio of the total muscle mass as well as the muscle mass of the lower limbs.
3. Muscle mass deficit in the lower limbs depends on the degree of spasticity of the proximal muscle groups of the lower limbs.

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