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Influence of selected perinatal factors on differentiation of anthropometric parameters in group of preterm children assessed at ages 5-8 years.

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Abstract

Background: In Poland, like in other developed countries, 6.3% babies are born prematurely. Preterm babies suffer from numerous health issues. The aim of this study was to determine whether such factors as being born from the first or subsequent pregnancy, single- or multi-fetal pregnancy, term and way of delivery, Apgar score at fifth minute of life and birth weight influence value of anthropometric parameters in preterm children at the late preschool age.

Method and materials: The study population consisted of 61 children, five to eight years old, who had been preterm born. The study was conducted in the years 2015-2016. The anthropometric measurements were taken according to international anthropometric methodology. We included the following anthropometric parametres: weight, height, chest circumference, BMI, Rohrer's Index, Marty's Index, thickness of skinfolds in three points: Over the triceps brachii muscle, in the umbiculus area, and at the scapula angle, as well as the general adiposity. For each of the children we calculated the z-score in reference to their age and gender. The reference values had been presented earlier.

Results: The values that were below zero and above -1 for and Me - the parameters that characterize the z-score - revealed that the study population in general had lower values for all assessed anthropometric features than the reference values for general population. There was a statistically significant relationship between thickness of skinfolds in the umbiculus area and number of foetuses (p=0.007).

Conclusion: 1. Preterm children who are about to start school have significantly lower values of anthropometric features that characterize their body. 2. Among preterm children, assessed at the late preschool age, only number of foetuses is a factor that differentiates the umbilical skinfold thickness.

Keywords: Pre-term children, Somatic development, Pre-school age.

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Introduction

In Poland, 6.3% babies are born prematurely [1,2]. This index is similar to other developed countries (5-10%) [2]. Extrauterine development of preterm babies, born between 27th and 37th week of gestation, is different from both the extrauterine development of babies born on time, and from intrauterine development of foetuses of the same gestational age [3]. In Poland preterm babies receive coordinated multidisciplinary care in the first 36 months of their lives due to a diverse perinatal interview, numerous health issues, including somatic development disorders [4]. It seems though that this period is not long enough and that it should be extended until the child is about to enter health school readiness phase. School readiness is assessed during one year compulsory pre-school kindergarten programme (the "0" class) or in the first semester of the first class of primary school, at the threshold of school age. Because of the education reform introduced in Poland in the years 2015-2016, children attending class "0" are five or six year old, and those at grade one are six or seven year old. The health school readiness is the state when there is balance between school's requirements and the child's abilities in terms of the physical (including somatic), cognitive and socio-emotional development [5]. The system of coordinated care comprises of i.e., assessment of school readiness, monitoring of somatic development including: the growth process, the differentiation of body proportion and composition [4]. Positive measures of somatic development are such anthropometric features as: body weight, body height, chest circumference, thickness of skinfolds: over the triceps brachii muscle, in the umbiculus area, and at the scapula angle, as well as the anthopometric coefficients [6-8]. WHO standards are recommended for assessment of physical development of children in the first three years of their lives. For older children, Polish developmental norms are recommended [9-11]. It is interesting whether such factors as being born from the first or subsequent pregnancy, single- or multi-fetal pregnancy, term and way of delivery, Apgar score at fifth minute of life and birth weight influence value of anthropometric parameters in preterm children at the late preschool age.

Aim of the Study

In Poland, 6.3% babies are born prematurely [1,2]. This index is similar to other developed countries (5-10%) [2]. Extrauterine development of preterm babies, born between 27th and 37th week of gestation, is different from both the extrauterine development of babies born on time, and from intrauterine development of foetuses of the same gestational age [3]. In Poland preterm babies receive coordinated multidisciplinary care in the first 36 months of their lives due to a diverse perinatal interview, numerous health issues, including somatic development disorders [4]. It seems though that this period is not long enough and that it should be extended until the child is about to enter health school readiness phase. School readiness is assessed during one year compulsory pre-school kindergarten programme (the "0" class) or in the first semester of the first class of primary school, at the threshold of school age. Because of the education reform introduced in Poland in the years 2015-2016, children attending class "0" are five or six year old, and those at grade one are six or seven year old. The health school readiness is the state when there is balance between school's requirements and the child's abilities in terms of the physical (including somatic), cognitive and socio-emotional development [5]. The system of coordinated care comprises of i.e., assessment of school readiness, monitoring of somatic development including: the growth process, the differentiation of body proportion and composition [4]. Positive measures of somatic development are such anthropometric features as: body weight, body height, chest circumference, thickness of skinfolds: over the triceps brachii muscle, in the umbiculus area, and at the scapula angle, as well as the anthopometric coefficients [6-8]. WHO standards are recommended for assessment of physical development of children in the first three years of their lives. For older children, Polish developmental norms are recommended [9-11]. It is interesting whether such factors as being born from the first or subsequent pregnancy, single- or multi-fetal pregnancy, term and way of delivery, Apgar score at fifth minute of life and birth weight influence value of anthropometric parameters in preterm children at the late preschool age.

Materials and Methods

The consent to conduct the study was obtained from the Bioethics Commission at the Medical Department of the University of Rzeszow (first resolution 7/12/2012, last resolution 6/2/2017). The study was conducted in the years 2015-2016 at the Institute of Physiotherapy of the University of Rzeszow and at the Centre for Innovative Research in Medical and Natural Sciences, Medical Faculty of University of Rzeszow. The parents of all participating children were informed about the purpose of the study and, in each individual case, they gave permission to participate.

Out of 200 pre-maturely born children hospitalized in the Clinical Regional Hospital No. 2 in Rzeszow invited to the study, 62 children responded positively and 61 completed the full study. Finally, the study population consisted of 61 children, five to eight years old, who had been preterm born. The study was conducted before the children started school [5]. The significant diversity in the age of the study populations resulted from the fact that some of the children were qualified to start school a year earlier, while some others obtained permission to start school a year later (6.38 years, Me=6 years, S=0.73). The study population consisted of 29 boys (48%) and 32 girls (52%). It comprised all available children at the moment.

We performed a perinatal questionnaire and observed lack of homogeneity in terms of perinatal interview. We learned that the study population children were born from pregnancies of various order, e.g. first, second etc. (Table 1A), from either single or multiple pregnancy (Table 1B), of premature delivery (Table 1C), through caesarean section or vaginal delivery (1D). They were born in different health condition (Table 1E) and had different body mass (Table 1F). Although some of preterm children suffered because of various complications typical for postnatal (adaptive) period, yet this problem was not considered in our study.

Table 1. *Characteristics of the examined group.*

A. Sequence of pregnancies	**N**	**%**
Child from Ist pregnancy	31	51
Child from IInd pregnancy	15	25
Child from IIIrd pregnancy	5	8
Child from IVth pregnancy	5	8
Child from Vth pregnancy	2	3
Child from VIth pregnancy	3	5
B. Number of fetuses	**N**	**%**
Unifetal pregnancy	39	64
Twin pregnancy	13	21
Triple pregnancy	9	15
C. Time of delivery (in weeks)	**N**	**%**
24	2	3
25	0	0
26	4	7
27	6	10
28	8	13
29	1	2
30	10	16
31	5	8
32	23	38
33	0	0
34	1	2
35	1	2
D. Way of delivery	**N**	**%**
Natural	10	16
Caesarean section	51	84

E. Assessment in the Apgar scale /5th minute after birth	N	%
0-3	9	15
4-7	39	64
8-10	13	21
F. Body mass at birth	**N**	**%**
Less than 750 g	3	5
750 g- 1000 g	10	16
1000 g – 1500 g	21	34
1500 g - 2500 g	26	43
2500 g- 3500 g	1	2

The assessment of somatic development consisted in taking anthropometric measurements: body weight (W), body height [B-v] (H), chest circumference [xi] (CC), Triceps Skinfold Thickness (TST), Subscapular Skinfold Thickness (SST), Umbilical Skinfold Thickness (UST) and calculating proportion indices. We used the following proportion indices: the Quetelet index derived from the mass and height (kg/m^2 WQ2, Body Mass Index, BMI), Rohrer's Index (g/cm^3, RI), Marty's Index (chest growth, MI), as well as total sum of the above parameters - the Global Adiposity (GA) [6-8]. The obtained data were compared with the biological reference system and interpretation of the obtained results [7,8]. The biological reference system were the data presented by Perenc et al., in accordance with the methodology of this study [7,8]. For each of the children, and for each of the parameters, we calculated the z-score in reference to their age and gender. The anthropometric measurements were taken according to international anthropometric methodology. We used medical scales (kg), anthropometer (cm), and anthropometric tape (cm), the body fat caliper (mm). We analyzed the obtained material according to accepted norms [5-8]. We categorized body built in reference to the absolute values of Rohrer's index based on Wanke's classification for boys and on Kolasa's classification for girls [6,7]. We identified the distortions to the growth process in reference to the traditional definition [12]. We categorized nourishment state in reference to the z-score BMI values [13] interpretation of the indices.

The statistical analysis took into consideration the differences in somatic development occurring between two genders. Also, statistical correlations between basic, above mentioned, elements of perinatal interview (1A-1F) and absolute values of anthropometric parameters were calculated.

Methods for Statistical Analysis

We conducted the statistical analysis of the obtained material in the Statictica 10.0 software package of the StatSoft Company. We used the W Shapiro-Wilk test to verify if the distribution of the studied variables was normal. Also we used the Student t-test to assess differences in the mean value of the numerical feature in two populations for independent variables, or, alternatively, the non-parametric Mann-Whithey U-test. We used the one-way Anova test to assess differences in mean value of numeric feature in more than two populations, or, alternatively, the non-parametric Kruskal-Wallis Anova. The Spearman's rank correlation coefficient was used to determine correlations of two variables that did not meet the criterion of normal distribution. And finally, we used Pearson's chi-squared test to analyze variables that were qualitative data. Statistical significance was assumed at $p<0.05$.

Results

Developmental level of preterm children at the late preschool age

The values that were below zero and above -1 for and Me - the parameters that characterize the z-score - revealed that the study population in general had lower values for the following features: W, H, and CC (Table 2A), BMI, RI and MI (Table 2B), TST, SST, UST and GA (Table 2C) than the reference values for general population.

Differentiation of body proportions and disorders in somatic development in preterm children at the late preschool age

We identified the distortions to the growth process in reference to the traditional definition (Table 2D) [12]. 5% of the studied population were short in stature and 5% were tall in stature (Table 2D). We categorized body built in reference to the absolute values of Rohrer's index based on Wanke's classification for boys and on Kolasa's classification for girls [6,7]. We categorized nourishment status in reference to the z-score BMI values [13] (Tables 2E and 2F). For studied boys, the dominant body built was medium and for studied girls the dominant body built was slender (Table 2E). 34.5% of the study population had weight deficiencies (11.5% were malnourished, and 23% were underweight) (Table 2F).

Table 2. *Z-score values of selected anthropometric parameters in the examined group*

A. Z-score indices of anthropometric characteristics					
Variables	**x̄**	**Me**	**S**	**Min**	**Max**
z-score W	-0.61	-0.67	1.08	-2.68	3.48
z-score H	-0.39	-0.42	1.02	-2.69	2.3
z-score CC	-0.61	-0.62	1.15	-2.79	5.56
B. Z-score values calculated for the proportion indices					
Variables	**x̄**	**Me**	**S**	**Min**	**Max**
z-score BMI	-0.65	-0.68	1.37	-4.03	6.35
z-score RI	-0.49	-0.52	1.36	-3.44	6.31
z-score MI	-0.44	-0.36	1.38	-3.55	5.94
C. Z-score indices of anthropometric characteristics of adiposity					
Variables	**x̄**	**Me**	**S**	**Min**	**Max**
z-score TST	-0.59	-0.79	1.14	-3.64	2.8
z-score SST	-0.17	-0.29	0.93	-1.37	4.9
z-score UST	-0.68	-0.75	0.68	-2.02	2.21
z-score GA	-0.57	-0.67	0.86	-1.86	3.46

D. Definition of growth disorders based on z-score H value and their prevalence		
Low-stature	**Correct H**	**High stature**
z-score [B-v]<-2	-2≥z -score [B-v]≤ 2	z-score [B-v]>2

3 (5%)		55 (90%)		3 (5%)	
E. Body-build based on Rohrer index					
Females (Kolasa system)			**Males (Wanke system)**		
slender	**Average**	**corpulent**	**Slender**	**Average**	**corpulent**
20(62.5%)	10(31.2%)	2(6.3%)	9(31.0%)	12(41.4%)	8(27.6%)
F. State of nutrition based on the BMI z-score in the examined group					
State of nutrition		**Definition**		**N (%)**	
Malnutrition		z-score BMI<-1,64		7 (11.5%)	
Underweight		-1,64≥z -score h< -1		14 (23.0%)	
Correct state of nutrition		-1≥z -score BMI≤ 1		38 (62.3%)	
Overweight		1>z -score BMI≤ 1,64		1 (1.6%)	
Obesity		z-score BMI>1,64		1 (1.6%)	

Growth process, gender, basic elements of perinatal interview

There was a statistically significant relationship between the CC value for girls and boys (p=0.029) - boys had greater values. There were no statistically significant relationships between W and H values (p>0.05) (Table 3A). We found no statistically significant relationships between anthropometric features and the number of pregnancy (p>0.05) (Table 3B), There also were no statistically significant relationships between anthropometric features and the number of foetuses in one pregnancy (p>0.5). The relationship for H was close to the significance threshold value (p=0.081). There were noticeable differences for H value for children from single pregnancies and multiple pregnancies (twin or triplet) - children from multiple pregnancies were shorter (Table 3C). There were no statistically significant differences between the gestational week of delivery and anthropometric features that characterize the growth process in studied children (p>0.05) (Table 3D). There were no statistically significant relationships between the anthropometric features and the kind of delivery (i.e., caesarean section vs. vaginal delivery) (p>0.05) (Table 3E). There were no statistically significant relationships between anthropometric features and a baby's Apgar score at their 5th minute after birth (p>0.05) (Table 3F). There were no statistically significant relationships between the anthropometric features and birth weight (p>0.05) (Table 3G).

Table 3. *Comparison of anthropometric characteristics of the examined groups.*

A. Comparison of anthropometric characteristics according to gender										
	Females				**Males**					
Variable	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**p**			
W (kg)	20.73	20	4.42	21.32	20.3	4.68	Z=-0.36 p=0.712			
H (cm)	116.18	116.1	6.73	117.04	115.7	6.26	t=-0.51 p=0.607			
CC (cm)	54.45	53.5	4.54	56.72	56	4.78	Z=-2.17 p=0.029			
U Mann-Whitney test (Z) ; Student t-test for independent variables										
B. Comparison of anthropometric characteristics according to sequence of pregnancy										
	Ist pregnancy			**IInd pregnancy**			**IIIrd pregnancy**			
Variable	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**p**
W (kg)	20.63	20.3	3.81	22.18	20.5	6.2	20.63	20	4.02	H=0.40 p=0.815
H (cm)	116.42	115.6	6.68	117.19	116.7	6.99	116.33	115.2	5.87	F=0.08 p=0.919
CC (cm)	55.07	55.5	3.35	56.83	55.5	7.06	55.17	55.5	4.54	H=0.13 p=0.934
Tests: Anova Kruskal-Wallis (H); unifactoral variance analysis Anova – Fischer-Snedocor test (F)										
C. Comparison of anthropometric characteristics according to number of fetuses										
	Unifetal pregnancy			**Twin pregnancy**			**Triple pregnancy**			
Variable	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**p**
W (kg)	21.94	21	4.85	19.22	20	4.01	19.57	19.4	2.37	H=3.99 p=0.135
H (cm)	117.96	117.2	7.07	113.85	114.5	5.14	114.58	115	3.3	F=2.61 p=0.081
CC (cm)	56.14	55.5	5.28	54.57	55.5	3.61	54.28	54	3.55	H=1.01 p=0.601
Tests: Anova Kruskal-Wallis (H); unifactoral variance analysis Anova – Fischer-Snedocor test (F)										
D. Dependence between anthropometric characteristics and time of delivery										
Variable pairs	**R**	**p**								
W (kg) vs. week of delivery	-0.06	0.633								
H (cm) vs. week of delivery	-0.1	0.461								
CC (cm) vs. week of delivery	-0.05	0.696								
Spearman's rank correlation coefficient										

E. Comparison of anthropometric characteristics according to way of delivery										
	Natural delivery			**Caesarean section**						
Variable	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**p**			
W (kg)	21.37	20.75	3.14	20.94	20	4.76	U=221.5 p=0.519			
H (cm)	116.66	116.6	6.8	116.57	116	6.47	t=0.03 p=0.968			
CC (cm)	55.58	55.65	4.27	55.52	55.5	4.88	U=245.0 p=0.855			
Tests: U Mann-Whitney (U); Student t-test for independent variables (t)										
F. Comparison of anthropometric characteristics according to the Apgar scale										
	0-3 pts.			**4-7 pts.**			**8-10 pts.**			
Variable	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**p**
W (kg)	20.1	19.5	4.51	21.49	20.3	4.66	20.18	21	4.2	H=0.60 p=0.739
H (cm)	114.23	114.5	7.36	117.08	115.7	6.39	116.74	117.5	6.25	F=0.70 p=0.498
CC (cm)	55.26	54	4.61	55.85	55.5	4.66	54.75	56	5.4	H=0.35 p=0.837
Tests: Anova Kruskal-Wallis (H); unifactoral variance analysis Anova – Fischer-Snedocor test (F)										
G. Comparison of anthropometric characteristics according to body mass at birth										
	750-1500 g			**1500-2500 g**			**2500-3500 g**			
Variable	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**p**
W (kg)	20.78	20	4.68	19.91	19.5	3.35	21.97	22	5.14	H=2.13 p=0.343
H (cm)	116.88	115.6	7.31	115.12	116	6.21	117.59	117	6.28	F=0.87 p=0.423
CC (cm)	55.72	55.5	3.54	54.52	54	3.09	56.22	56	6.14	H=0.79 p=0.672
Tests: Anova Kruskal-Wallis (H); unifactoral variance analysis Anova – Fischer-Snedocor test (F)										

Body proportions, gender, basic elements of perinatal interview

We did not find statistically significant relationships between gender and proportion indices (p>0.05) (Table 4A). There were no statistically significant relationships between proportion indices and the number of pregnancy (p>0.05) (Table 4B). We did not find statistically significant relationships between proportion indices and the number of foetuses (p>0.05) (Table 4C). There were no statistically significant relationships between the gestational week of delivery and proportion indices (p>0.05) (Table 4D). There were no statistically significant relationships between the proportion indices and the kind of delivery (i.e., caesarean section vs. vaginal delivery) (p>0.05) (Table 4E). There were no statistically significant relationships between a baby's Apgar score at their 5th minute after birth and proportion indices (p>0.05) (Table 4F). There were no statistically significant relationships between the birth weight and proportion indices (p>0.05) (Table 4G).

Table 4. *Characteristics of the proportion indices in the examined groups.*

A. Comparison of the proportion indices according to gender										
Variables	**Females**			**Males**						
	x̄	**Me**	**S**	**x̄**	**Me**	**S**	**p**			
BMI	15.23	15.25	2.2	15.5	15.27	2.7	Z=0.13 p=0.890			
RI	1.31	1.32	0.18	1.33	1.33	0.23	Z=0.07 p=0.936			
MI	46.91	47.1	3.31	48.5	48.43	3.69	Z=-1.56 p=0.117			
U Mann-Whitney test (Z)										
B. Comparison of the proportion indices according to sequence of pregnancy										
Variables	**Ist pregnancy**			**IInd pregnancy**			**IIIrd pregnancy**			
	x̄	**Me**	**S**	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	p
BMI	15.13	15.19	1.85	16.07	15.23	3.8	15.11	15.5	1.68	H=0.07 p=0.694
RI	1.3	1.34	0.16	1.37	1.31	0.32	1.3	1.32	0.11	H=0.18 p=0.909
MI	47.37	47.91	2.69	48.53	46.8	5.53	47.4	48.15	2.65	H=0.06 p=0.969
Anova Kruskal-Wallis test (H)										
C. Comparison of the proportion indices according to number of fetuses										

Variables	**Unifetal pregnancy**			**Twin pregnancy**			**Triple pregnancy**			
	x̄	**Me**	**S**	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**p**
BMI	15.67	15.27	2.62	14.73	15.26	2.32	14.89	15.03	1.54	H=0.78 p=0.674
RI	1.33	1.32	0.22	1.29	1.33	0.19	1.3	1.27	0.14	H=0.02 p=0.985
MI	47.64	46.99	4.1	47.92	48.44	2.11	47.38	47.34	2.83	H=0.94 p=0.624
Anova Kruskala-Wallisa test (H)										
D. Comparison of the proportion indices according to time of delivery										
Variable pairs	**R**	**p**								
BMI vs week of delivery	-0.07	0.57								
RI vs week of delivery	0.02	0.874								
MI vs week of delivery	0.03	0.798								
Spearman's rank correlation coefficient										
E. Comparison of the proportion indices according to way of delivery										
Variables	**Natural**			**Caesarean section**						
	x̄	**Me**	**S**	**x̄**	**Me**	**S**	**p**			
BMI	15.68	15.25	1.7	15.29	15.26	2.56	U=236.0 p=0.722			
RI	1.35	1.32	0.17	131	1.32	0.21	U=229.0 p=0.624			
MI	47.8	48.14	4.57	47.64	47.53	3.38	U=234.0 p=0.693			
U Mann-Whitney test (U)										
F. Comparison of the proportion indices according to the Apgar scale										
Variable	**0-3 pts.**			**4-7 pts.**			**8-10 pts.**			
	x̄	**Me**	**S**	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**p**
BMI	15.26	15.75	2.12	15.59	15.27	2.5	14.73	14.6	2.5	H=1.70 p=0.425
RI	1.34	1.4	0.18	1.33	1.33	0.21	1.26	1.22	0.21	H=2.27 p=0.320
MI	48.34	47.91	1.68	47.75	47.29	3.56	46.96	47.34	4.52	H=1.00 p=0.605
Anova Kruskal-Wallis test (H)										
G. Comparison of the proportion indices according to body mass at birth										
Variable	**750-1500 g**			**1500-2500 g**			**2500-3500 g**			
	x̄	**Me**	**S**	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**p**
BMI	15.03	14.93	1.72	14.95	15.34	1.57	15.83	15.43	3.16	H=0.79 p=0.671
RI	1.29	1.31	0.12	1.3	1.31	0.14	1.35	1.36	0.27	H=0.84 p=0.655
MI	47.7	48.44	1.85	47.42	47.53	2.52	47.84	47.34	4.76	H=0.13 p=0.933
Anova Kruskal-Wallis test (H)										

Body composition, gender, basic elements of perinatal interview

We found a statistically significant relationship between the gender and GA (p=0.039). The relationships between gender and TST (p=0.068) and between gender and SST (p=0.054) were close to the statistical significance. The GA value and both skinfold values were higher in females (Table 5A). We observed no statistically significant relationships between anthropometric parameters and the number of pregnancy (p≥0.05), yet we noted lower values for third and subsequent pregnancies, close to statistical significance: TST (p=0.057), SST (p=0.069) and GA (p=0.050) (Table 5B).

Table 5. *Characteristics of anthropometric parameters related to body adiposity.*

A. Comparison of anthropometric parameters according to gender										
	Females			**Males**						
Variables	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**p**			
TST (mm)	11.5	12	4.465	9.86	9	4.18	Z=1.82 p=0.068			

SST (mm)	8.06	8	2.687	7.38	6	4.01	Z=1.93 p=0.054			
UST (mm)	7.03	6	4.076	6.41	6	4.4	Z=0.63 p=0.527			
GA	26.59	26	9.561	23.66	22	11.97	Z=2.05 p=0.039			
Test U Mann-Whitney test (Z)										
B. Comparison of anthropometric parameters according to sequence of pregnancy										
	Ist pregnancy			**IInd pregnancy**			**IIIrd pregnancy**			
Variables	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**p**
TST (mm)	11.19	11	4.08	11.8	10	4.83	8.67	8	4.1	H=5.70 p=0.057
SST (mm)	8.1	7	2.94	8.33	7	4.59	6.4	6	2.56	H=5.32 p=0.069
UST (mm)	6.9	6	3.59	7.67	6	5.54	5.47	4	3.85	H=4.05 p=0.131
GA	26.19	24	9.04	27.8	23	14.07	20.53	18	9.61	H=5.96 p=0.050
Anova Kruskal-Wallis test (H)										
C. Comparison of anthropometric parameters according to number of fetuses										
	Unifetal pregnancy			**Twin pregnancy**			**Triple pregnancy**			
Variables	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**p**
TST (mm)	10.87	10	4.58	11.54	12	4.29	8.89	8	3.33	H=3.04 p=0.218
SST (mm)	8.21	7	3.57	7.54	7	3.43	6	6	1.58	H=4.40 p=0.110
UST (mm)	7.51	6	4.65	6.54	6	3.18	3.67	4	1.12	H=9.80 p=0.007
GA	26.59	23	11.7	25.62	24	9.52	18.56	18	5.2	H=5.73 p=0.056
Anova Kruskal-Wallis (H); test post-hoc (multiple comparison test)										
D. Dependence between anthropometric parameters and time of delivery										
Variable pairs	**R**	**p**								
TST (mm) vs week of delivery	0.12	0.328								
SST (mm) vs week of delivery	-0.03	0.812								
UST (mm) vs week of delivery	0.09	0.478								
GA vs week of delivery	0.72	0.468								
Spearman's rank correlation coefficient										
E. Comparison of anthropometric parameters according to way of delivery										
	Natural delivery			**Caesarean section**						
Variables	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**p**			
TST (mm)	10.8	10.5	2.82	10.71	10	4.64	U=237.0 p=0.737			
SST (mm)	8.5	8	3.1	7.59	7	3.43	U=195.0 p=0.250			
UST (mm)	7.8	6	4.13	6.53	6	4.23	U=204.0 p=0.330			
GA	27.1	24.5	8.92	24.82	23	11.15	U=210.5 p=0.391			
U Mann-Whitney test (U)										
F. Comparison of anthropometric parameters according to the Apgar scale										
	0-3 pts.			**4-7 pts.**			**8-10 pts.**			
Variables	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**x̄**	**Me**	**S**	**p**
TST (mm)	12.89	13	3.79	10.54	10	4.47	9.77	9	4.28	H=3.78 p=0.150
SST (mm)	7.78	7	2.39	8.05	7	3.8	6.77	6	2.42	H=1.26 p=0.531
UST (mm)	7.56	5	4.07	6.64	6	4.39	6.46	5	3.97	H=0.41 p=0.813
GA	28.22	28	8.27	25.23	23	11.66	23	22	9.65	H=3.59 p=0.166
Anova Kruskal-Wallis test (H)										
G. Comparison of anthropometric parameters according to body mass at birth										
	750-1500 g			**1500-2500 g**			**2500-3500 g**			

Variables	x̄	Me	S	x̄	Me	S	x̄	Me	S	p
TST (mm)	10.5	9	4.74	9.1	10	3.77	11.93	10	4.38	H=3.44 p=0.178
SST (mm)	8.15	7	3.29	7.05	7	2.42	8.07	7	4.02	H=0.55 p=0.759
UST (mm)	7	6	4.49	5.95	5	2.42	7.22	6	5.12	H=0.11 p=0.944
GA	26	21	11.78	22.1	23	6.96	27.22	24	12.44	H=1.51 p=0.469
Anova Kruskal-Wallis test (H)										

There was a statistically significant relationship between UST and number of foetuses (p=0.007) - the UST parameter decreased with increasing number of foetuses. Post-hoc test (multiple comparisons test) revealed statistically significant differences between the value of this parameter for single and triplet pregnancies (p=0.005). It did not reveal, however, significant differences between single and twin pregnancies (p=1.000) or between twin and triplet pregnancies (p=0.051); though in the latter case the relationship was close to statistical significance. We found that the relationship between GA and the number of foetuses was close to statistical significance threshold (p=0.056). The most noticeable difference for this parameter was between single pregnancies or twin pregnancies and triplet pregnancies (Table 5C). There were no statistically significant relationships between the gestational week of delivery and anthropometric parameters related to body adiposity (p>0.05) (Table 4D). We did not find statistically significant relationships between anthropometric parameters and the kind of delivery (p>0.05) (Table 5E). There were no statistically significant relationships between a baby's Apgar score at their 5th minute after birth and anthropometric parameters (p>0.05) (Table 5F). Also, there were no statistically significant relationships between birth weight and anthropometric parameters (p>0.05) (Table 5G).

Discussion

The studied anthropometric features of W, H and CC are positive indicators of growth process. They are used for characterizing the growth of the body, and therefore enable an assessment of somatic development [14]. Using proportion indices of BMI, RI and MI enabled us to follow the differentiation of body proportions (its typology) as well as the nourishment status. Some authors stress that BMI does not show the total content of fat tissue in a body, and that it only shows the weight to height proportions [15]. Others decided that RI is the optimal weight to height ratio characterizing nourishment state. For this index, the weight correlation value equals the alienation index [16]. Currently, proportion indices other than BMI are rarely used for purposes of assessment of: weight to height proportion differentiation and nourishment state [14,17,18]. Obesity related complications and risk of premature death are usually assessed in relation to the BMI [19]. Poland currently uses growth charts to assess the BMI of children 3 to 18 years old. The design of these growth charts followed the OLAF and OLA projects [10]. It is believed that the WHtR (Waist/Height Ratio) [20,21] or densitometry [17] allow for forecasting and diagnosis of abdominal obesity in children. High correlation has been found between GA and BMI [17], and skinfold thickness of TST, SST, UST and GA are considered to be the relevant measurements of adiposity [18,19,22]. It is known that adipokines concentration in blood reflects the activity of adipose tissue [23].

In five to eight year old children from the reference population, we noted a regular increase in W and CC for both genders. We proved the occurrence of prepubescent ("school age") jump in H for boys aged five to six and for girls aged six to seven [7]. Preterm children from the study population had lower values for W, H and CC at the threshold age of school readiness than children from the reference population. The and Me values characterizing distribution of z-score indices calculated for W, H, CC were in the range of 0 to -1.

The literature presents several studies from numerous countries on preterm children. For instance, an Estonian study on 155 two-year olds [24] or a Turkish study on 34 preschool children indicated a lower level of growth in this group of subjects [25]. A Texas study on 137 children born on time and 96 preterm children found that preterm children had lower H values at their 30th month of life [26].

In our study, the incidence of short stature and tall stature in preterm children was 5% each. Another study, conducted in Czech Republic, confirmed incidence of short stature in preterm children [27]. Górniak et al. studied incidence of short in stature and tall in stature in 15 046 boys aged seven to nineteen in the Eastern Voivodeships of Poland (Podlaskie, Lubelskie and Podkarpackie Voivodeships). 5.3% boys were short-statured and 3.8% were tall-statured [28].

Studied preterm children had significantly lower values of BMI, RI, MI, TST, SST, UST and GA than children from the reference group at the age known as "school readiness threshold". According to growth reference charts, male and female children from Rzeszów aged five to eight had good nourishment status, especially in reference with BMI. Among the studied proportion indices a significant increase in RI value was found only in girls aged five to six and seven to eight; and a significant increase of MI was found only in boys aged seven to eight [7]. In boys and girls aged five to eight from the reference groups, the pace of growth of skinfold: TST, SST, UST and GA was rather stable [8].

In our study on a population of preterm children the incidence of underweight was significant. 34.5% preterm children were underweight, while 3.2% were overweight. A prospective study on 4501 children found various patterns of weight to height proportion differentiation in the first three years of life in preterm children. For these children, the BMI increases may be similar to those for children born on time for the whole period of the first five years of their lives. They may also increase sharply for their first two years of life to remain stable later on; or may increase gradually yet slower for the whole period of infancy and early childhood; or even increase significantly slower, in particular in the first three years of life [29]. Among preterm children obesity increases with age. The risk of developing obesity increases in children who were born at more mature gestational age and with greater birth weight, as well as in those who in their second year of life had significantly greater body mass when compared to their peers [30]. In other studies, waist circumference was significantly greater in preterm children at the age of two years, and the BMI was similar to their peers from the growth reference charts. At the age of five waist circumference was similar, while BMI was significantly lower. It has been concluded that this fact points to an increase of content of visceral fat in preterm children [21]. A study on five year old preterm children has found that extremely premature children (born before 26th week gestational age) had similar global adiposity (GA) based on measurements of ten skinfolds as children born in the 26th gestational week and later [27]. It seems that in some regions of Poland the problem of body mass deficiency occurs more often than its excess. A population study of Polish children aged seven to nine found overweight in 15% of boys and 15.8% of girls, with 3.6% boys and 3.7% girls being obese [31]. In the Podlaskie region, a study on 591 children aged 1 to 14 found that the incidence of underweight was 24.2% and the incidence of overweight was 12.5%. Most of the underweight children lived in families who could not afford to pay rent and buy enough food [32]. In the Warminsko-Mazurskie region, the dominant body built type was slender, and the underweight in children up to eight years old is common [19]. A study on 610 children aged six to 13 from the city of Lodz found an impact of environment pollution on BMI. Children from the polluted city centre had lower BMI [33]. In the Podkarpackie region, the environmental contrasts still present in the 21st century affected the typology of BMI, MI and RI and were usually lower in rural children than in urban children [34]. Numerous other countries recognize the effect of socioeconomic factors. In Poland, a factor that resulted in lowering the risk of abdominal obesity was high socioeconomic status [35]. A study from United States confirmed that low socioeconomic status is connected with greater skinfold thickness in adolescents [36]. In United Kingdom it is stressed that educative activities which level socioeconomic differences should be conducted in families with preschool children [37]. A European study on 168 832 children aged six to nine was conducted in 2007 and 2008. It found that underweight was rare. The incidence of overweight and obesity was similar in boys (19.3-49.0%) and in girls (18.4-42.5%). The study found a north-south gradient in incidence of overweight, with the highest incidence in the South European countries [38]. In Asia, study in West China on child development found an increasing tendency for incidence of overweight and obesity, accompanied by a simultaneous high incidence of malnutrition [39].

The hypothesis of higher eco-sensitivity in boys than in girls is widely known. It states that the H development path is less distorted under environmental modifiers in girls and therefore the body height development path is different for both genders. In the Podkarpackie Voivodeship these differences in development path in two genders were still observed [34]. In our studies this phenomenon was not observed. Differences in CC values in girls and boys are seen as being characteristic for sexual dimorphism [40]. Our study found that CC took statistically significantly higher absolute values in boys than in girls. In other studies on preterm children, boys had higher increases of weight until the 30th month of age and had higher head circumference at the 30th month of age [26]. Differences in body build between boys and girls were observed. In preterm boys the dominant body build was medium, and in preterm girls the dominant body build was slender. In reference populations, boys aged five to six had stout body built, and boys aged seven to eight had medium body built. In girls aged five eight the dominant body build was medium, and only girls aged seven had slender body build. Male aged five to eight had lower MI values than females [7]. Statistically significant relationship was found between gender and GA. Preterm females had higher GA values, closer to the reference ones. It is known that the incidence of excessive adipose tissue in children and adolescents depends on age and gender. In Portugal, in children older than nine years obesity increased in girls and decreased in boys [41]. Preterm born adults, in particular men, had significantly increased fat content, and its location suggested abdominal obesity. Similarly, unfavourable distribution of fat tissue was found in their children who had been born on time. Simultaneously, the study found the impact of preterm birth of the parents on obesity in their children [17].

There are many examples of dependence between complications of postnatal period (adaptive) and level of somatic development and its disorders. It has been found that at their 30th month of age pre-term children with high medical risks had significantly lower H, head circumference and neurological development level than children born on time with low neurological risk. The high medical risks were: bronchopulmunary dysplasia, intraventricular hemorrage grade III or grade IV, periventricular leukomalacia [26]. A study on 37 preterm children found that the development of bronchopulmunary dysplasia in infancy results in lowering the values of W, H and head circumference at the age of two [42]. In preterm children, severe brain damage is a risk factor for underweight [24]. In this study such dependencies were not analyzed.

The size of birth parameters such as W, H, head circumference and CC depend on gestational age [43]. In the past it was believed that to assess body height of preterm children it is enough to calculate their corrected age and compare it with normative values for children born on time whose age and gender corresponded to the corrected age and gender of the preterm child. This rule proved inefficient in body mass assessment. Hence, in 1995 in Poland, Niedźwiedzka and Palczewska designed growth charts for W and H assessment of preterm children from birth to 36th month of life. The normative systems were presented separately for males and females, as well as separately for delivery before 32 weeks gestational age and for 32 to 37 weeks gestational age [3]. Interestingly, in our study the values of and Me for the body height z-score of preterm children were closest to the values for children from the reference population. We did not find statistical relationship between values of anthropometric features and the gestational week of delivery. The studies on ways of growth monitoring of preterm children are currently being updated worldwide [44].

Preterm birth, similarly to birth from multiple pregnancies, is a factor that distorts development [45]. Of 130 children born from multiple pregnancies studied by Chlebna-Sokół et al. 23.9% had lower than normal values of W and H [1]. Our study found that the relationship between H and the number of foetuses was close to statistical significance. Children from multiple pregnancies had lower H. Our study showed that preterm children from multiple pregnancies had significantly lower UST. It has been found that lower adipokines value was related to preterm birth and to low birth weight in relation to gestational age regardless of whether the child was born from single or twin pregnancy [23]. An increased risk of developing obesity at preschool age was found in children from caesarean sections. The relationship has been found in a study on 1255 children delivered either vaginally or by caesarean section. The children had assessment of nutrition at the age of three [46]. TST, SST and GA depended on the number of pregnancy in a way that was close to statistical significance. In children from the third and subsequent deliveries these parameters had slightly lower values. It has been found that the number of pregnancy, along with the mother's age, her education, the kind of her occupation and material status impacts her dietary habits [47]. Women who were born from first pregnancies have greater tendency for obesity than their sisters from subsequent sisters [48].

It is important to consider that short or medium body height of mother, tall body height of father, significant difference of body height of mother and father contribute to the development of mother-foetus disproportion, related to genetically determined large body of the foetus and, simultaneously, to the decision of caesarean delivery [49]. Interestingly, mothers who had BMI values suggesting obesity had increased risk of undergoing induced preterm delivery due to medical reasons [50]. Obesity in mothers of preterm children were also a risk factor of low development quotient in the second year of life [51]. It has been found that in the total population, preterm children or children with macrosomia, whose mothers were obese, had increased risk of obesity [39]. These examples imply the need of education strategies aiming at curbing obesity cycle across generations [52].

The growth level of children, including preterm ones, has some prognostic value. A French study on 4501 preterm children found differences in their somatic development patterns, and noted that children who had slowest somatic development scored low in cognitive development assessment [29]. Another studies showed that premature children who did not have early school related problems, had higher increases in head circumference in infancy and early childhood [53]. Birth weight of over 4500g is a significant risk factor for obesity in adolescence [54]. Our study did not find relationships between birth weight and skinfold thickness.

It is known that a well-balanced diet is an important positive modifier of the growth process of both preterm children and healthy children [55]. Still, not all commonly used dietary practices have been studied enough to determine their impact on the growth process [56]. It is known that a well-balanced diet in early childhood is necessary for the physical, psychological and social development. It has been found that early childhood malnutrition is a risk factor of high concentration of glucose, high blood pressure and harmful lipid profile, particularly if the BMI increases later in life [57]. Moreover, malnutrition in the prenatal period, infancy and early childhood till the third year of life affects negatively the psychomotor development and immunity [9,58]. The incidence of obesity is increasing worldwide, resulting in increased incidence of metabolic diseases and disorders in adulthood and in shortened lifespan [59]. There is a relationship between healthy diet, optimal nourishment in early childhood and good health in adulthood [9]. Therefore dietary recommendations, diet assessment and nourishment assessment are important and interrelated issues [58,60]. The NutricheQ questionnaire is a valid tool for assessing the quality of preschool children diet. The questionnaire allows for identification of unbalanced and poor quality diet [61]. Polish personal child health records contain relevant reference systems for assessment of children's development [9-11], yet their application is not satisfactory [58]. Excessive consumption of energy rich food stimulates the development of adipose tissue [62]. Currently, carefully programmed diet from the earliest moments of life is considered to be preventive action against non-infectious chronic diseases: hypertension, obesity, type 2 diabetes, dyslipidemia, osteoporosis, food allergy and cancer. It also affects positively child psychomotor development [58]. Well-oriented physical activity plays an important role, too - in eight to twelve year olds, body adiposity decreases with increased physical activity [63]. In preschool children, general function decreases with increased skinfold thickness, particularly on the trunk [64]. In children with low birth weight and neurodevelopmental deficits necessitate introduction of dietary supplements. Introduction of dietary supplements leads to increased growth process, but also to an increase in visceral fat [65]. However, introduction of dietary intervention in preterm children requires careful monitoring of their body mass [66,67].

Conclusion

The value of the study is the number of parameters we analyzed. So far, there has not been a study that would analyze all these parameters simultaneously. Also, a significant value of the study is the fact that it was conducted on preterm children as they were entering school age. Until now, most of such studies were conducted on preterm children by the age of three. The limitation of the study is the small study population

1. Preterm children who are about to start school have significantly lower values of anthropometric features that characterize their body. 2. Among preterm children, assessed at the late preschool age, only the number of foetuses is a factor that differentiates the umbilical skinfold thickness.

Declarations

Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authors' contribution

LP contributed to the design, performed the statistical analyses, drafted and finalised the manuscript; KZ contributed substantially to the design, conception, data collection, analysis and interpretation of data; JD-G contributed substantially to the design, data collection, reading of the script; JM contributed substantially to interpretation of data, and drafting of the work; BC-G participated in the data analysis and critically reviewed the manuscript; KW-C critically reviewed the manuscript. All authors contributed to the design of the study and interpretation of results, and approved the final version of the manuscript.

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