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ANTHROPOMETRIC ANALYSIS OF THE PHYSICAL DEVELOPMENT OF PRE-SCHOOL CHILDREN FROM SLOVAKIA

ABSTRACT: In this study we compare somatic parameters of preschool-age children. The research was carried out in preschool facilities in the Sabinov district, Slovakia, in four age categories from 3 to 6 years. Anthropometric measurement involves the evaluation of 16 anthropometric parameters. We performed the following anthropometric measurements: Sitting height (M23), Arm span (M17), Upper limb length (M54), Lower limb length (M53), Biacromial breadth (M35), Transverse chest diameter (M36:), Bispinal breadth (M41), Maximum head length (M1b), Maximum head breadth (M3), Breadth of the face (M6), Morphological height of the face (M18), Hand length (M49), Hand width (M52), Forearm length (M48), Foot length (M58) and Foot width (M59). The results confirmed changes in parameters depending on age and gender. In the results, higher average values were recorded in boys than in girls in almost all measured parameters, and even younger boys demonstrated higher values than older girls.

KEY WORDS: Pre-school children - Anthropometric analysis - Anthropometric measurement - Sabinov district - Slovakia.

INTRODUCTION

Anthropometry is a methodical approach that deals with the study of the human body (Fredriks *et al.* 2000, Bogin, Varela-Silva 2010, Contreras *et al.* 2014) and is helpful for obtaining data that can be used in ergonomics and industry (Knight 1999, Paschoarelli 2000, Prado-León 2001, Szeto 2002, Brewer 2009, Saarni 2007, Chung 2007, Trevelyan 2011, Capatan *et al.* 2014, Jervas 2015, Spahiu 2015, Lu 2017, Cheng 2019). Similarly, these data are also a particularly important indicator of the health status of individuals (De Onis *et al.* 1996).

Proper growth and development are conditioned by several factors, such as hygienic conditions, the social environment, diet, physical activity and many others, which can positively but also negatively affect the

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acceleration of individual growth (Duranková *et al.* 2018). They are also important because preschool age is a period when the most significant somatic changes occur; therefore, we consider anthropometric research, especially in this period, to be very valuable and significant (Kopecký *et al.* 2013). Nevertheless, there is no comprehensive study on the same issue to compare with the data presented in this study. We present partial results from ongoing research focused on the creation of national standards – thus far lacking – for anthropometric parameters in Slovakia. Therefore, it is highly necessary that the goal of anthropometric research be extensive samples of probands and updated data. In addition, new anthropometric parameters that may be helpful in clinical practice in the future should be introduced. Therefore, in the present work, we have selected such dimensions for anthropometric measurements that may be useful in the future for paediatricians, neurologists, maxillofacial orthopaedists, paediatric surgeons, geneticists and other specialized doctors.

Although several authors have dealt with the measurement of various anthropometric parameters (whether in preschool or school children or adults), these measurements were performed in correlation with a disease or malformation (Neščáková 2019, Mihalovičová 2018). This is why our obtained results could not be compared with their results, since they dealt with the same measurements in their work, but with a different age group (Fuchsová 2017).

Several previous studies have compared the somatic parameters of preschool children (Becker-Christensen 2003, Frederiks *et al.* 2005, Cheng *et al.* 2018, Merker *et al.* 2018, Pino *et al.* 2018). Cheng *et al.* (2018) conducted anthropometric research in Taiwan, where they determined the anthropometric parameters of the length of the upper limb, the length and width of the leg, the length and width of the hand and the length and width of the face in children aged 2 to 6 years old. Merker *et al.* (2018) determined in their research the body height while sitting, the length of the leg, the span of the shoulders and the length of the foot. Pino *et al.* (2018), Becker-Christensen (2003) and Frederiks *et al.* (2005) performed anthropometric research of several measures as a tool for monitoring growth.

This study was undertaken because new reports on the anthropometric variability of children from Slovakia (Central Europe) are still insufficient. We provided morphological analyses of preschool children of age 3 to 6 years old. Accordingly, the main purpose of our research was to contribute to knowledge on quantitative characteristics of the size of sixteen body variables, describe their variability and test the impact of sexual dimorphism on morphological variation.

MATERIAL AND METHODS

We evaluated sixteen anthropometric parameters of preschool children from the majority ethnic group from eastern Slovakia (the Sabinov district). Our dataset consisted of 104 children (56 boys and 48 girls) aged 3 to 6 years old. We performed the following anthropometric measurements: Sitting height (M23: vertex point and a table), Arm span (M17: dactylion-dactylion, Upper limb length (M54), Lower limb length (M53), Biacromial breadth (M35), Transverse chest diameter (M36: mesosternale), Bispinal breadth (M41: the distance between the iliospinale points measured from the front), Maximum head length (M1b: glabella-opisthocranion), Maximum head breadth (M3: euryon-euryon), Breadth of the face (M6: zygion-zygion), Morphological height of the face (M18: nasion-gnathion), Hand length (M49), Hand width (M52), Forearm length [M48: obtained by deduction of the dimension M9 (height to the radiale point) to the dimension M10 (height to the stylion point)], Foot length (M58) and Foot width (M59).

All parameters were measured according to the recommendations of the International Standards for Anthropometric Assessment (Martin, Saler 1953, Kopecký *et al.* 2013) and by using classical anthropological instruments. The obtained dataset was evaluated using the following statistical parameters: range value, i.e. mean (M), standard deviation (SD), standard error (SEM), 95% confidence interval (95% CI) and coefficient of variation (V). Normal distribution was tested using the D'Agostino-Pearson omnibus K^2 test and the Shapiro-Wilk normality test. We also used a two-way ANOVA with age and sex as factors to also test for their interactions and to evaluate the statistical significance of the variability.

Anthropometric measurements were performed with the consent of the principals of the nursery schools. Informed consent was also provided by the parents of the children. The requested data were anonymous, and the children participated in the measurement voluntarily. In physiologically healthy children, 16 anthropometric parameters were measured separately for each proband. All measurements were made exclusively by one author (ZJ) of the presented study in order to avoid measurement inaccuracies.

TABLE 1: Average values of anthropometric dimensions of preschool children from Slovakia. M, boys; F, girls; SD, standard deviation; SEM, standard error of mean; V, coefficient of variation in %.

Sitting height (M23)														
Age	**N**		**Mean**		**SD**		**SEM**		**95% CI**				**V (%)**	
									Lower		**Upper**			
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
3	13	12	59.16	57.61	1.33	1.65	0.36	0.47	58.36	56.56	59.97	58.66	1.70	2.56
4	15	12	59.69	58.16	1.41	1.61	0.41	0.46	58.80	57.11	60.59	59.17	1.82	2.72
5	14	11	65.58	60.50	3.44	1.52	0.92	1.60	63.59	58.16	67.57	62.90	4.91	6.52
6	14	13	65.88	61.71	2.14	3.78	0.56	1.50	69.69	62.47	67.12	66.04	2.85	3.62
Arm span (M17)														
3	13	12	98.89	94.89	3.30	5.83	0.84	1.68	97.11	91.19	100.80	96.60	3.63	1.56
4	15	12	107.30	100.30	3.63	10.10	0.93	2.89	105.3	93.92	109.30	106.60	4.78	3.96
5	14	11	116.80	109.50	6.37	10.54	1.70	3.17	113.10	102.40	120.40	116.60	4.21	3.68
6	14	13	120.80	113.00	6.52	3.62	1.74	1.00	117.10	110.80	124.60	115.20	4.52	4.68
Upper limb length (M54)														
3	13	12	42.15	39.17	4.75	2.43	1.31	0.70	39.28	38.16	45.03	41.26	6.30	6.12
4	15	12	46.54	44.80	3.80	0.74	1.10	0.21	44.83	44.32	48.25	45.28	6.34	4.56
5	14	11	50.62	52.52	3.87	5.50	1.30	1.52	48.38	49.13	52.86	55.91	9.35	8.42
6	14	13	52.13	49.45	3.37	3.22	0.90	0.89	50.18	47.51	54.08	51.40	7.67	6.21
Lower limb length (M53)														
3	13	12	50.82	50.53	1.70	0.81	0.47	0.23	49.80	50.01	51.85	51.04	2.17	1.35
4	15	12	56.03	53.76	5.30	2.30	1.30	0.58	53.24	52.46	58.81	55.05	8.19	4.65
5	14	11	61.04	58.49	4.60	3.20	1.80	0.91	59.09	56.46	63.79	60.52	5.52	9.10
6	14	13	63.58	61.73	4.50	3.50	1.80	0.97	61.24	59.61	65.92	63.85	6.14	5.32
Biacromial breadth (M35)														
3	13	12	25.32	25.80	0.83	1.16	0.23	0.33	24.82	24.34	25.83	25.81	3.78	4.45
4	15	12	24.63	25.36	2.55	1.83	0.65	0.53	23.21	24.19	36.04	26.53	3.29	5.27
5	14	11	27.51	27.35	1.62	1.80	0.43	0.32	26.57	26.65	28.44	28.40	6.23	4.35
6	14	13	27.19	26.75	1.40	1.14	0.27	0.32	26.58	26.50	27.79	27.45	2.55	2.65
Transverse chest diameter (M36)														
3	13	12	27.19	26.75	1.40	1.15	0.27	0.32	26.58	26.50	27.79	27.45	6.25	2.47
4	15	12	16.31	16.30	0.81	1.32	0.22	0.38	15.82	15.18	16.80	16.87	5.18	4.75
5	14	11	18.99	19.47	1.30	1.49	0.34	0.45	18.24	18.47	19.74	20.48	2.88	2.45
6	14	13	19.40	19.80	0.61	0.42	0.10	1.52	19.40	18.16	17.76	20.00	4.10	3.55
Bispinal breadth (M41)														
3	13	12	19.55	19.70	1.73	1.90	0.48	0.31	18.60	18.37	20.70	19.76	4.13	4.21
4	15	12	21.20	21.17	1.80	1.66	0.27	0.48	20.42	20.11	21.62	22.22	5.14	4.72
5	14	11	23.18	22.64	1.86	1.49	0.49	0.44	22.10	21.64	24.25	23.64	8.25	4.21
6	14	13	23.14	22.90	1.38	1.25	0.37	0.34	22.33	22.14	23.94	23.66	8.76	8.39
Maximum head length (M1b)														
Age	**N**		**Mean**		**SD**		**SEM**		**95% CI**				**V (%)**	
									Lower		**Upper**			
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
3	13	12	16.73	16.68	0.46	0.52	0.12	0.15	16.45	16.34	17.10	17.10	3.97	2.84
4	15	12	16.23	16.51	0.87	1.90	0.22	0.31	15.75	15.81	16.72	17.21	2.14	1.98
5	14	11	17.00	16.58	0.99	1.29	0.20	0.39	16.11	15.71	17.34	17.45	2.56	5.26
6	14	13	16.76	16.84	0.92	1.38	0.24	0.38	16.23	16.00	17.30	19.68	4.21	2.45
Maximum head breadth (M3)														
3	13	12	12.82	13.62	0.64	1.88	0.17	0.54	12.43	12.42	13.21	14.82	2.67	3.84
4	15	12	13.10	13.40	0.75	1.60	0.19	0.30	12.68	12.72	13.20	14.80	1.68	2.30
5	14	11	13.41	14.10	1.40	0.78	0.27	0.23	13.81	13.57	14.10	14.62	3.85	3.15
6	14	13	13.51	14.20	0.58	1.26	0.15	0.35	13.17	13.25	13.84	14.78	5.93	3.66

TABLE 1: Continued.

Breadth of the face (M6)														
3	13	12	9.70	9.50	0.32	0.40	0.08	0.11	9.51	9.25	9.90	9.76	3.46	3.35
4	15	12	9.56	9.61	1.26	0.97	0.32	0.28	8.86	8.99	10.26	10.23	3.83	5.21
5	14	11	9.98	10.11	0.67	0.66	0.20	0.17	9.52	9.72	10.44	10.49	5.84	6.10
6	14	13	10.11	10.13	0.57	0.81	0.15	0.22	9.50	9.64	10.45	10.26	4.63	4.68
Morphological height of the face (M18)														
3	13	12	7.60	7.30	0.72	0.35	0.20	0.10	7.20	7.80	8.70	7.53	9.15	5.17
4	15	12	9.30	8.44	1.12	1.23	0.26	0.32	8.73	7.76	9.86	7.13	4.93	12.59
5	14	11	9.22	8.80	0.91	1.16	0.24	0.34	8.69	8.20	9.75	9.58	8.95	13.66
6	14	13	9.28	9.32	0.54	1.10	0.14	0.28	8.97	8.70	9.60	9.93	5.47	7.80
Hand length (M49)														
3	13	12	11.20	10.81	0.48	0.59	0.13	0.17	10.71	10.43	11.32	11.18	5.17	6.59
4	15	12	11.89	11.30	0.69	0.57	0.16	0.16	11.54	10.94	12.25	11.66	4.43	5.60
5	14	11	12.61	12.16	0.95	0.75	0.25	0.22	12.60	11.60	13.16	12.60	4.35	3.84
6	14	13	13.15	12.63	1.23	1.90	0.32	0.30	12.44	11.97	13.86	13.29	5.75	2.58
Hand width (M52)														
3	13	12	6.70	6.49	0.40	0.56	0.11	0.16	6.52	6.13	7.10	6.85	10.58	10.38
4	15	12	6.80	6.20	0.56	0.78	0.14	0.22	6.52	5.52	7.15	6.52	10.35	8.86
5	14	11	7.50	6.91	0.22	0.54	0.82	0.16	6.57	6.55	7.52	7.28	6.41	6.79
6	14	13	7.25	7.14	0.71	0.50	0.18	0.14	6.84	6.84	7.66	7.45	8.42	8.76
Forearm length (M48)														
3	13	12	16.87	17.57	0.63	2.60	0.17	0.59	16.59	16.26	17.25	18.88	5.61	6.94
4	15	12	18.64	19.17	0.69	1.46	0.18	0.42	18.25	18.23	19.30	20.10	2.10	5.97
5	14	11	20.80	20.10	1.50	1.77	0.40	0.53	19.93	18.94	21.67	21.31	6.28	7.68
6	14	13	21.76	19.65	1.45	1.34	0.38	0.37	20.92	18.84	22.60	20.47	7.11	2.19
Foot length (M58)														
3	13	12	16.33	16.30	0.54	0.42	0.15	0.12	16.00	15.76	16.66	16.30	3.10	3.28
4	15	12	16.97	16.44	1.39	0.42	0.36	0.12	16.19	16.10	17.74	16.71	2.34	1.82
5	14	11	18.69	18.36	1.34	1.13	0.36	0.34	17.91	17.60	19.47	19.12	4.18	5.45
6	14	13	19.18	17.69	0.08	1.81	0.21	0.50	18.72	16.59	19.64	18.79	8.63	3.77
Foot width (M59)														
3	13	12	6.82	6.60	0.40	0.48	0.13	0.11	6.58	6.35	7.60	6.96	2.10	3.80
4	15	12	6.92	6.89	0.43	0.40	0.10	0.15	6.68	6.63	7.16	7.14	5.42	12.50
5	14	11	6.92	6.71	0.86	0.63	0.15	0.15	6.42	6.36	7.42	7.21	5.28	4.64
6	14	13	7.00	7.37	0.68	0.31	0.17	0.08	6.60	7.21	7.39	7.53	3.88	6.28

All descriptive analyses and the two-way ANOVA were performed using MS Excel 2003 for Windows XP and the statistical software OriginPro8.6 (Microral Software Inc., Northampton, USA).

RESULTS

The descriptive statistics for each measurement considered are reported in *Table 1*, with the samples divided into sexes. The values of the measured parameters increased continuously with age, and we recorded higher average values in boys than in girls in almost all the measured parameters. Moreover, the coefficient of variation (V) was higher than 5.0% for almost all measures in the age categories, indicating larger variability. This can be explained by the fact that children are growing up and growth was not complete.

The somatic measurements in genders overlapped, and multivariate analysis (two-way ANOVA) confirmed significant differences between them (*Table 2*).

DISCUSSION

As already mentioned, finding relevant literature on similar issues was very difficult, as most authors report measurements in connection with ergonomics and the

TABLE 2: Results of two-way ANOVA measured body parameters – preschool age boys. BP, body parameters; df, degree of freedom; SSq, Sum of square; Significant variables are shown with the significant levels: *p<0.05. **p<0.01. ***p<0.001., p – statistic significant.

Variables	Effect	df	SSq	MSq	F-value	p-value	
M23	Age	3	798.57	266.19	38.76	1.11E-16	***
	Sex	1	166.11	166.11	24.19	3.48E-06	***
	Age x Sex	4	961.73	240.43	35.01	0	***
M17	Age	3	6397.09	2132.36	50.56	0	***
	Sex	1	1111.60	1111.60	26.36	1.42E-06	***
	Age x Sex	4	7525.89	1881.47	44.61	0	***
M54	Age	3	1825.63	608.54	46.93	0	***
	Sex	1	42.73	42.73	3.30	0.07251	***
	Age x Sex	4	1875.07	468.77	36.15	0	***
M53	Age	3	2319.34	773.11	38.05	2.22E-16	***
	Sex	1	57.99	57.99	2.86	0.09426	
	Age x Sex	4	2378.12	594.53	29.26	4.44E-16	***
M35	Age	3	120.95	40.32	17.20	4.56E-09	***
	Sex	1	0.01	0.01	0.06	0.94097	
	Age x Sex	4	120.97	30.24	12.90	1.71E-08	***
M36	Age	3	195.933	65.31	33.42	5.22E-15	***
	Sex	1	0.13	0.13	0.07	0.79836	
	Age x Sex	4	196.10	49.03	25.09	2.33E-14	***
M1b	Age	3	2.96	0.99	1.02	0.38764	
	Sex	1	0.05	0.05	0.05	0.82912	
	Age x Sex	4	3.0249	0.76	0.78	0.53978	
M3	Age	3	6.89	2.30	2.08	0.10771	
	Sex	1	8.31	8.31	7.53	0.00721	***
	Age x Sex	4	15.20	3.80	3.44	0.0112	*
M6	Age	3	6.33	2.11	3.56	0.017	*
	Sex	1	0.09	0.09	0.15241	0.69709	
	Age x Sex	4	6.42	1.61	2.7053	0.03461	*
M18	Age	3	57.19	19.06	24.95	4.19E-12	***
	Sex	1	3.76	3.76	4.92	0.02887	*
	Age x Sex	4	61.48	15.37	20.12	3.79E-12	***
M49	Age	3	61.31	20.44	29.39	1.13E-13	***
	Sex	1	4.73	4.73	6.80	0.01054	*
	Age x Sex	4	66.10	16.53	23.77	8.55E-14	***
M52	Age	3	8.85	2.95	7.24	1.93E-04	***
	Sex	1	2.95	2.95	7.24	0.00836	***
	Age x Sex	4	11.67	2.92	7.16	4.17E-05	***
M48	Age	3	206.80	68.93	30.28	5.64E-14	***
	Sex	1	4.28	4.28	1.88	0.17353	
	Age x Sex	4	211.60	52.89	23.24	1.46E-13	***
M58	Age	3	110.99	36.99	29.25	1.26E-13	***
	Sex	1	11.74	11.74	9.28	0.00297	***
	Age x Sex	4	123.12	30.78	24.33	4.88E-14	***
M59	Age	3	2.69	0.89	2.87	0.04016	*
	Sex	1	0.01	0.01	0.03	0.86727	
	Age x Sex	4	2.705	0.68	2.16	0.07858	

clothing industry, or in correlation with various diseases. Nevertheless, anthropometry and its results are also very important and an integral part for practical use in, e.g. clothing design, industrial design and architecture. The results of anthropometric studies provide very important data for ergonomics, i.e. the science dealing with the relationship between human beings and the environment. Its main goal is to prepare material for relevant experts (architect, designer, etc.), on the basis of which it would be possible to create working conditions that support optimal human performance, prevent possible injuries and lead to increased comfort. Published data on anthropometric parameters (Merker *et al.* 2018, Cheng *et al.* 2019) are necessary to confirm, for example, that physical symptoms in children may be related to "bad" school furniture. According to Iyer (2001), these symptoms included neck and shoulder pain associated with poor posture. The author believes that improper carrying of a school backpack was associated with chronic musculoskeletal pain in schoolchildren. The discrepancy between the physical dimensions of the body and the school furniture in the classroom can also be associated with mobility difficulties. Therefore, school furniture was also designed to positively influence students' learning behaviour and overall health (Knight, Noyes 1999, Iyer 2001).

Further, data on the size of school furniture are needed, and not only in Slovakia. It should be noted that the above-mentioned studies mostly concerned older age groups (school age, adulthood). Several studies have shown that musculoskeletal symptoms are one of the ten most common health problems, and that these symptoms are typical for other countries, too, and not only in older school-age children and adolescents (Knight, Noyes 1999, Paschoarelli, da Silva 2000, Prado-León *et al.* 2001, Saarni *et al.* 2007, Chung, Wong 2007, Brewer *et al.* 2009, Trevelyan, Legg 2011, Lu, Lu 2017, Cheng *et al.* 2019).

However, it should also be noted that not only different ethnicity (Wagner, Heyward 2000, Deurenberg *et al.* 2003, Kagawa *et al.* 2007, Sampei *et al.* 2008), but also nutrition, different lifestyle and the environment most likely play an important role that contributes to differences in body size and dimensions (Agarwal 1994).

Therefore, our preliminary study provides very important and necessary data, usable in the future for the correct design of school furniture. Nevertheless, long-term studies on a large sample of children and students should be conducted for the proper design of school furniture and thus to improve the health of adolescents.

CONCLUSION

The main aim of the present study was to compare different anthropometric parameters of preschool children. The data presented in this study are also very important for filling the gap in the data related to this area of anthropological research in Slovakia. The body structure of a child at this age is changing much faster than at other ages and therefore should be the subject of more research, not only in the field of health, but also in the field of clothing and industrial design. Poor living conditions, inadequate diet, lack of physical activity and many other adverse factors affect physical development, which in some cases has been confirmed in our work.

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