Savko Jekić, Ph.D., Miroljub Grozdanović, Ph.D.,
Dragan Golubović, Ph.D., Evica Stojiljković, Ph.D.

Playground equipment in the function of didactic games

Pregledni znanstveni članek

UDK 684.4:373.2

KLJUČNE BESEDE: ergonomsko projektiranje, pohišđtvo za otroke, antropometrične mere

POVZETEK – Igrača je pomembno vzgojno-izobraževalno sredstvo. Ni druge stvari na svetu, ki bi bila tako privlačna za otroke in bi tako izpolnila njihov čustveni svet, kot ga lahko igrača. Z njeno pomočjo otroci razvijajo svoje čute in mišice, učijo se družabnosti. Igrače prispevajo k razvoju inteligence in pomagajo pri učenju. Razvijajo ustvarjalnega duha pri otrocih in prispevajo k razvoju komunikacijskih veščin. Sodobne igrače morajo biti ergonomsko zasnovane zaradi varnosti in zdravja otrok v času igre. Namen tega prispevka je predstaviti rezultate statičnih in dinamičnih antropometričnih meritevdimenzij predšolskih otrok iz osrednje Srbije. Merjenja smo izvedli v vrtcu v vseh treh starostnih skupinah (3-4 leta, 4-5 let, 5-6 let). V raziskavi smo definirali skupaj 32 statičnih in 15 dinamičnih antropometričnih količin. Ugotovili smo, da na osnovi statičnih in dinamičnih antropometričnih izmer lahko lahko izboljša varnost, funkcionalnost in udobje uporabnikov.

Review scientific paper

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KEYWORDS: ergonomic design, child's playground equipment, anthropometric measurements

ABSTRACT – A toy is considered as a highly important pedagogical and educational instrument. There is no other object in the world that attracts a child as a toy does. Nothing fulfills the child's emotional world like a toy. A toy helps the child develop senses and muscles as well adopt the rules of social behavior. The toy plays an important role in intellectual development and assists the learning process. It improves creativity and contributes to the advancement of communication skills of a child. Modern toys offered to children should be ergonomically designed in order to improve the safety and health of the children during a game. Given that, the aim of this paper to present the results of static and dynamic anthropometry of the body dimensions of pre-school children (from Central Serbia). The measurements concerned three age groups of children: junior (3-4 years old), middle (4-5 years old) and senior (5-6 years old). For the purposes of this project, a list of 32 static and 15 dynamic anthropometric measurements of arm and leg outreach of the children were done.

1. Introduction

A toy is considered as a highly important pedagogical and educational instrument.

The great importance of a toy for physiological and physical development of a child is well described by E. Seguen: "Books can never teach what toys can yield to a child…if you observe what kind of toys your children prefer, you will be able to predict what kind of persons they will grow up to be" (Jekić, 2011).

There is no other object in the world that attracts a child as a toy does. Nothing fulfills the child's emotional world like a toy. A toy helps the child develop senses and

muscles as well adopt the rules of social behavior. The toy plays an important role in intellectual development and assists the learning process. It improves creativity and contributes to the advancement of communication skills of a child.

Modern toys should be ergonomically designed to match the form of the child's hand and other body dimensions of the child (height, weight). They should fit the current level of the child's development, making it possible for children to handle toys according to their own ideas, without being exposed to any extra efforts.

The ergonomics of the children's playground equipment comprises two main areas: adapting the equipment (playground equipment) and the surrounding (playgrounds, venues, sport halls) to the child (child's age).

Serbia still does not have national anthropometric standards, since this requires large-scale measuring that should be performed on a high number of samples, followed by careful monitoring over a time span of two or more decades, which is an extremely costly undertaking.

National manufacturers of children's playground equipment have had to use foreign data on anthropometric measurements, and these had to be modified (since they could not be directly implemented) due to the existing anthropometric differences.

Considering the fact that in Serbia so far there have not been any projects that would encompass anthropometric measurements of the population on a national scale, this paper is the only valid source of relevant data. The obtained results of the static and dynamic anthropometric measurements of pre-school children can be used to introduce standards for dimensioning playground equipment, "safety zones" around playground features and playgrounds themselves.

2. Methodology

It is a widespread practice in Serbian kindergartens to classify children into (Kamenov, 1983, 1997, Eljkonin, 1981, Jekić, Golubović, 2006b): nursery, junior, middle and pre-school group, and toys are chosen in accordance with the age group of the children. Table 1 shows the age of the children who were the target group for this research.

Table 1. Age of children in pre-school institutions in Serbia

To 3 years old (nursery: crib age)	*3–4 years old (junior: young age group)*	*4–5 years old (middle: medium age group)*	*5–6 years old (senior: older age)*	*Over 7 years old (school age group)*
	Age group of children, users of playground equipment			

The measurements of the static anthropometric dimensions were done from 22-26 June 2006, while the dynamic measurements of outreach (arm and leg) were done from 15-26 June 2007, in the "Poletarac" kindergarten, a unit of the pre-school institution "Radost" in Čačak.

The data (body measurements of children) were recorded in a form of a graphic description of the child's body (in the standing and seating position, the palm of the hand and the foot), with pointers and fields for entering the measured values.

The results of the measured parameters, obtained on a sample of 65 children, are shown in the tables, according to their group classification: junior group (17 children), middle group (22 children), and senior, or pre-school group (26 children).

Based on the foreign (Motmans, 2005, McDowell et al., 2008, Кръстева, 2008, EN 1176:2008, CDC24/7, 2009, TU Delft, 2009a, 2009b) and domestic (Simić, 1991, Grozdanović, 1999, 2003, Klarin, Cvijanović, 2005) scientific literature, as well as the experience of the authors of this research, a list of required anthropometric measurements was compiled.

For the purposes of this project, a list of static anthropometric measurements was created, referring to various body measurements of pre-school children: 12 anthropometric measurements in the standing position; 11 anthropometric measurements in the seating position; 7 anthropometric measurements of body parts – the hand, foot and head which; together with two more measurements – shoe size and weight – make a list of 32 measurements.

For the purposes of the dynamic anthropometric measurements of the reach of the child's bodies, 15 measurements were selected. Seven of these measurements were done for the standing position, six for the seating position and two of the measurements referred to the hand and the foot. All of the measurements were selected to allow subsequent combinations, i.e. a mathematical calculation directed towards producing other measurements that can practically satisfy all the different needs of the manufacturers dealing with the production of various items to be used by the children of this age.

In planning and designing children's playground equipment, the ergonomic / anthropometric static body measurements of pre-school children can be a dominant factor. Therefore, it is necessary to adjust playground features with the anthropometric measurements of the children who are likely to use the given playground equipment and toys. That is the way to achieve significant improvements in safety, functionality, comfort and pleasure of playground users (i.e. children) and their parents or educators.

Table 2 contains all of the major static and dynamic measurements of arm and leg outreach of the children necessary for an appropriate design of playground equipment and playgrounds, as well as for a design of "safety zones" around the playgrounds' (Jekić, Golubović, 2006a, 2009).

Table 2. Most important static and dynamic measurements of the children

Static anthropometric measurements (choice of the so-called "great measurements")	*Dynamic anthropometric measurements*
A – Body height	$A_{din.max.}$ – The maximum height of reach by the hand (u in a standing position) $A_{din.nom.}$ – The normal height of reach by the hand (u in a standing position)
H – Shoulder width	$D_{din.max.}$ – The maximum height of raised foot, leg bent in the knee (in a standing position)
P – Height from seat to elbow	$E_{din.max.}$ – The maximum height of reach by the hand (in a sitting position) $E_{din.nom.}$ – The normal height of reach by the hand (in a sitting position)
U – Forearm length	$L_{din.max.}$ – The maximum measurements of lateral reach by the hand, with the body in a sitting position
V – Height from the bottom to the sitting part – behind the chair, bench	$G_{din.max.}$ – The maximum measurements of reach by the hand, while leaning forward (in a sitting position)
X – Width of the sitting part of the child in a sitting position	$S_{din.max.}$ – The maximum measurements of forward reach by the foot, in a sitting position
T – Calf length	Ø – The largest diameter of an imagined bar that can be grasped by the child's hand so that the thumb and the index finger touch – make contact
Y – Width of the child's head	Ψ – The largest rotation angle of the foot
Z, θ – Length of the child's palm	
Ω – Width between the palm and the thumb	
Ψ – Foot length (Φ) – Shoe size of the child	
Λ – The largest width of the foot (Φ) – Shoe size of the child	
Q – Body weight of the child	

3. Results

The safety of children who use playground equipment primarily depends on the engineering knowledge and the experience in choosing the material, as well as the calculation of the dimensions of the cross-section of the carrying elements and the joining elements of the structure (the frame of the structure). The implementation of this anthropometric results is supported by the implementation of the knowledge of the applied arts, psychology, etc. that will fully guarantee the pleasure and safety children – users of playground equipment, both during and after the game.

Table 3. Basic statistical data of static anthropometric measurements of pre-school children (all three age groups, n=61 children)

	Body weight (kg)	**Q**	1249.50	20.48	4.35	13.50	32.00	13.35	20.48	27.62
Anthropometric measurements of the palm, the foot and the head of the child	**Greatest width of foot**	**A**	497.30	8.15	0.93	6.80	10.50	6.63	8.15	9.68
	Length of foot	**Ψ**	1105.00	18.11	1.65	15.00	22.00	15.41	18.11	20.82
	Palm width with thumb	**Δ**	457.20	7.50	0.58	6.20	9.00	6.55	7.50	8.44
	Palm width without thumb	**Ω**	388.30	6.37	0.60	5.30	7.50	5.39	6.37	7.34
	Palm length to the finger	**Θ**	465.70	7.63	0.68	6.00	9.00	6.52	7.63	8.75
	Length of stretched palm	**Z**	800.10	13.12	1.04	11.00	15.00	11.41	13.12	14.82
	Child's head width	**Y**	862.10	14.13	0.71	13.00	17.00	12.97	14.13	15.29
Anthropometric measurements of the child's body in a siting position (cm)	**Width of sitting part**	**X**	1421.50	23.30	2.47	18.00	29.00	19.25	23.30	27.36
	Length from bottom to knees	**W**	2087.30	34.22	3.13	28.00	44.00	29.09	34.22	39.35
	Height from bottom to sitting part	**V**	1690.10	27.71	2.37	22.00	33.00	23.82	27.71	31.60
	Length of forearm	**U**	1519.90	24.92	2.45	20.50	31.30	20.89	24.92	28.94
	Length of calf of leg	**T**	1789.30	29.33	3.12	22.00	35.20	24.21	29.33	34.46
	Length of upperknees part	**S**	2233.30	36.61	4.01	30.30	45.00	30.04	36.61	43.19
	Height of thigh in sitting position	**R**	699.50	11.47	2.04	8.00	16.00	8.12	11.47	14.82
	Height from seat to elbow	**P**	941.80	15.44	2.75	10.50	23.00	10.93	15.44	19.95
	Height of shoulders	**O**	2324.00	38.10	3.88	31.00	46.00	31.74	38.10	44.46
	Height of eyes	**N**	3181.60	52.16	4.59	44.00	63.00	44.63	52.16	59.69
	Height of sitting	**M**	3821.90	62.65	4.96	50.60	74.00	54.51	62.65	70.80
Anthropometric measurements of the child's body in a standing position (cm)	**Span of streched arm**	**L**	5989.00	98.18	7.18	81.00	115.00	86.41	98.18	109.95
	Stomach obesity	**K**	915.30	15.00	2.12	10.80	21.00	11.52	15.00	18.49
	Width of thighs	**J**	1341.60	21.99	3.27	17.20	33.00	16.62	21.99	27.36
	Width of waist	**I**	1143.90	18.75	3.08	14.00	28.00	13.70	18.75	23.80
	Width of shoulders part	**H**	1708.30	28.00	2.72	22.30	36.20	23.54	28.00	32.47
	Length of extended arm	**G**	2940.30	48.20	4.79	39.50	61.00	40.35	48.20	56.05
	Height up to the knees	**F**	1880.80	30.83	2.90	25.50	39.00	26.07	30.83	35.59
	Height to the hand (palm)	**E**	2613.50	42.84	4.51	31.00	51.00	35.44	42.84	50.24
	Height up to the elbow	**D**	4107.70	67.34	5.59	57.00	80.00	58.17	67.34	76.51
	Height to sholders	**C**	5340.10	87.54	6.96	73.00	102.00	76.13	87.54	98.95
	Height to the eyes	**B**	6178.30	101.28	8.18	85.30	124.00	87.87	101.28	114.70
	Body height	**A**	6900.50	113.12	8.45	98.50	139.00	99.27	113.12	126.98
			Σ	$\overline{x}$	**σ**	X_{min}	X_{max}	P_5	P_{50}	P_{95}

Table 4. Correlation coefficients (r) of anthropometric measurements of pre-school children (all three age groups, n=61-children)

Sign of measure		Anthropometric measurements of the child's body in a standing position (cm)											Anthropometric measurements of the child's body in a siting position (cm)											Anthropometric measurements of the palm, the foot and the head of the child											
		Body height	Height to the eyes	Height to sholders	Height up to the elbow	Height to the hand (palm)	Height up to the knees	Length of extended arm	Width of shoulders part	Width of waist	Width of thighs	Stomach obesity	Span of streched arm	Height of sitting	Height of eyes	Height of shoulders	Height from seat to elbow	Height of thigh in sitting position	Length of upperknees part	Length to the calf of leg	Length of forearm	Height from bottom to sitting part	Length from bottom to knees	Width of sitting part	Child's head width	Length of stretched palm	Palm length to the finger	Palm width without thumb	Greatest palm width with thumb	Length of foot	Greatest width of foot	Body weight (kg)	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
		Ordinal number and sign of antropometrical value																																
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S	T	U	V	W	X	Y	Z	Θ	Ω	Δ	Ψ	Λ	Q		
A	1	1.00	0.97	0.92	0.93	0.54	0.91	0.77	0.68	0.42	0.49	0.30	0.86	0.86	0.83	0.71	0.50	0.66	0.87	0.74	0.64	0.87	0.92	0.57	0.36	0.86	0.75	0.68	0.64	0.87	0.66	0.81		
B	2		1.00	0.94	0.94	0.56	0.89	0.77	0.68	0.40	0.47	0.33	0.85	0.82	0.82	0.70	0.48	0.60	0.88	0.75	0.66	0.87	0.90	0.59	0.34	0.85	0.70	0.64	0.60	0.87	0.60	0.82		
C	3			1.00	0.92	0.66	0.88	0.76	0.75	0.50	0.56	0.44	0.83	0.79	0.75	0.75	0.49	0.57	0.84	0.79	0.72	0.81	0.85	0.63	0.39	0.82	0.69	0.57	0.59	0.84	0.51	0.83		
D	4				1.00	0.58	0.85	0.70	0.67	0.40	0.50	0.35	0.67	0.98	0.79	0.69	0.50	0.65	0.84	0.72	0.64	0.83	0.86	0.58	0.37	0.80	0.70	0.64	0.60	0.88	0.64	0.80		
E	5					1.00	0.54	0.32	0.56	0.47	0.49	0.35	0.37	0.51	0.41	0.58	0.50	0.26	0.39	0.44	0.45	0.44	0.45	0.38	0.24	0.44	0.29	0.16	0.32	0.51	0.07	0.44		
F	6						1.00	0.70	0.69	0.47	0.54	0.37	0.78	0.81	0.77	0.70	0.52	0.62	0.83	0.72	0.69	0.77	0.87	0.49	0.44	0.75	0.67	0.55	0.62	0.78	0.60	0.76		
G	7							1.00	0.48	0.31	0.32	0.31	0.82	0.60	0.52	0.47	0.20	0.51	0.74	0.73	0.61	0.79	0.78	0.49	0.16	0.70	0.67	0.41	0.40	0.69	0.36	0.67		
H	8								1.00	0.73	0.72	0.76	0.60	0.60	0.59	0.68	0.51	0.52	0.68	0.72	0.58	0.55	0.66	0.67	0.50	0.63	0.55	0.42	0.54	0.69	0.44	0.85		
I	9									1.00	0.92	0.72	0.34	0.44	0.39	0.59	0.55	0.43	0.40	0.51	0.53	0.29	0.45	0.52	0.64	0.61	0.47	0.40	0.41	0.47	0.33	0.57		
J	10										1.00	0.68	0.41	0.50	0.45	0.65	0.64	0.56	0.47	0.54	0.58	0.38	0.52	0.64	0.53	0.40	0.47	0.20	0.41	0.47	0.20	0.61		
K	11											1.00	0.35	0.30	0.26	0.43	0.36	0.34	0.43	0.51	0.48	0.25	0.38	0.57	0.41	0.31	0.31	0.16	0.31	0.35	0.20	0.61		
L	12												1.00	0.77	0.69	0.65	0.38	0.63	0.82	0.72	0.59	0.80	0.84	0.56	0.26	0.74	0.70	0.62	0.52	0.81	0.63	0.77		
M	13													1.00	0.88	0.81	0.58	0.62	0.71	0.60	0.55	0.76	0.79	0.56	0.33	0.76	0.79	0.63	0.69	0.80	0.62	0.75		
N	14														1.00	0.81	0.65	0.70	0.55	0.50	0.74	0.74	0.54	0.34	0.75	0.68	0.68	0.68	0.76	0.66	0.73		
O	15															1.00	0.75	0.64	0.60	0.57	0.55	0.64	0.67	0.59	0.38	0.66	0.57	0.46	0.57	0.66	0.48	0.65		
P	16																1.00	0.65	0.39	0.32	0.46	0.45	0.49	0.40	0.53	0.52	0.32	0.27	0.35	0.44	0.39	0.40		
R	17																	1.00	0.57	0.46	0.55	0.64	0.70	0.48	0.39	0.66	0.55	0.47	0.50	0.63	0.63	0.55		
S	18																		1.00	0.84	0.63	0.78	0.84	0.57	0.37	0.73	0.63	0.58	0.48	0.79	0.60	0.85		
T	19																			1.00	0.62	0.66	0.73	0.58	0.35	0.64	0.63	0.43	0.43	0.73	0.35	0.80		
U	20																				1.00	0.55	0.62	0.48	0.42	0.65	0.15	0.34	0.49	0.58	0.31	0.66		
V	21																					1.00	0.87	0.56	0.26	0.85	0.68	0.64	0.58	0.81	0.56	0.71		
W	22																						1.00	0.68	0.40	0.81	0.65	0.66	0.60	0.80	0.64	0.78		
X	23																							1.00	0.43	0.58	0.46	0.49	0.55	0.54	0.36	0.73		
Y	24																								1.00	0.30	0.17	0.18	0.28	0.24	0.29	0.38		
Z	25																									1.00	0.77	0.67	0.62	0.80	0.60	0.76		
Θ	26																										1.00	0.62	0.66	0.75	0.62	0.72		
Ω	27																											1.00	0.74	0.65	0.75	0.64		
Δ	28																												1.00	0.58	0.58	0.64		
Ψ	29																													1.00	0.65	0.82		
Λ	30																														1.00	4.82		
Q	31																															1.00		

3.1. Results of statistical anthropometric measurements

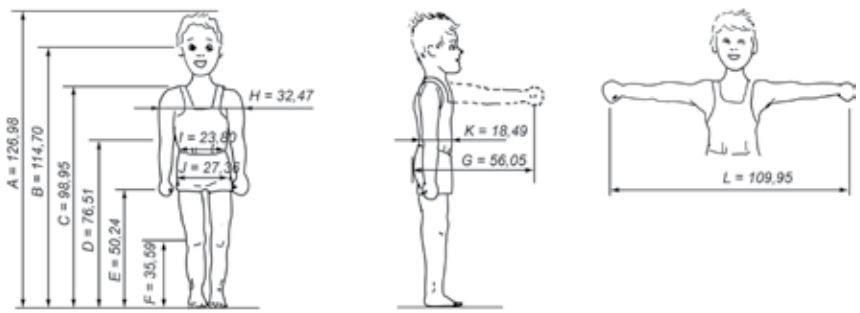
Table 3 present the calculation of the statistical data of the static anthropometric measurements of pre-school children, classified in three age groups. The mean value ($\overline{X}$), σ, the minimum ($x_{min.}$) and the maximum ($x_{max.}$), as well as the result of the research is expressed in the form of the centiles (percentiles) (P_5, P_{50}, P_{95}), which form the basis for the definition of the dimensions of playground equipment and objects used by children in general.

Table 4 shows the level of correlation among all the 32 body measurements of children. For example, the correlation between the height (measurement A) and the weight (measurement Q) is very high ('+' correlation, (0.81), while the correlation between the length of the forearm (measurement U) and the size of the waist (measurement K) is very small, almost insignificant (0.08).

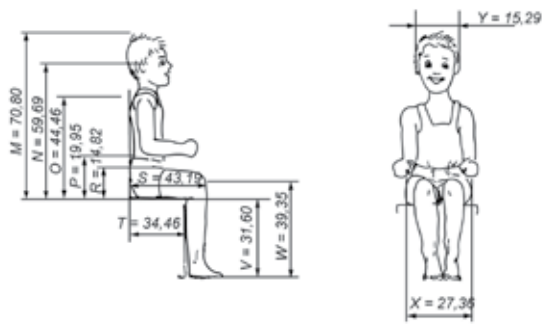
Figures 1, 2 and 3 yield very clear information regarding the static anthropometric measurements of pre-school children for the 5th, 50th and 95th percentile.

Figure 1. Static anthropometric measurements, for 95th centil (P_{95})

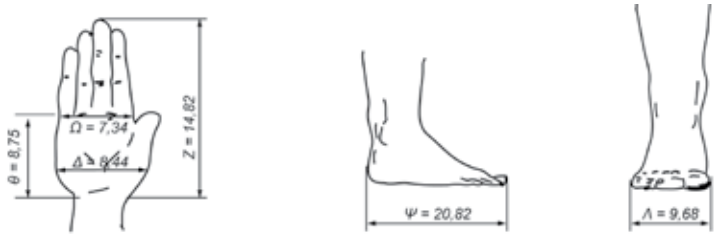
□ Static anthropometric measurements of the child's body in a standing position (Longitudinal measurements in cm, weight in kg)



□ Static anthropometric measurements of the child's body in a sitting position



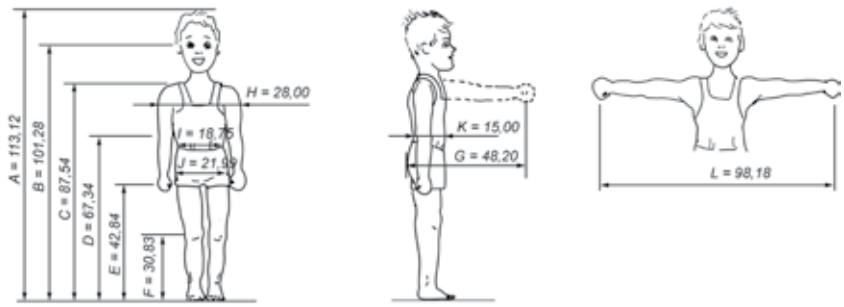
□ Anthropometric measurements of the child's hand and foot



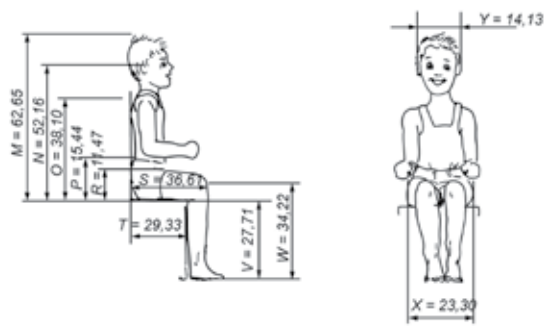
□ The child's weight: Q = 27.62 kg
□ The size of the child's shoes is: ≈ 31

Figure 2. Static anthropometric measurements, for 50th centil (P_{50})

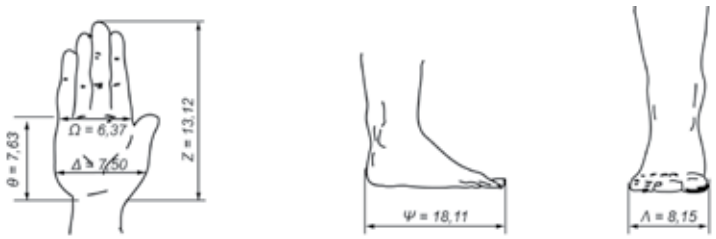
□ Static anthropometric measurements of the child body in a standing position (Longitudinal measurements in cm, weight in kg



□ Static anthropometric measurements of the child's body in a sitting position



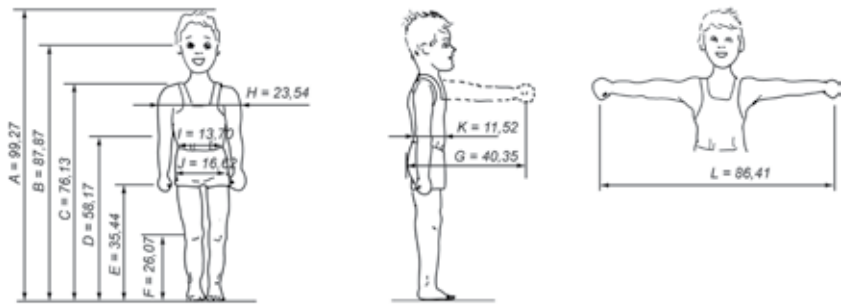
□ Anthropometric measurements of the child's hand and foot



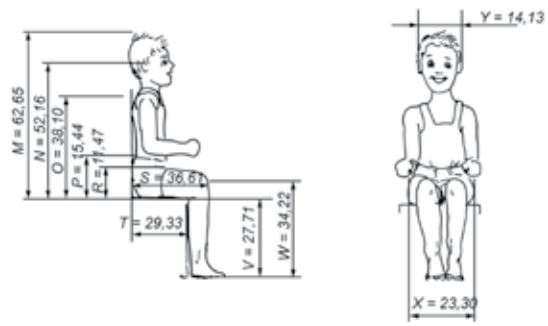
□ The child's weight is: Q = 20.48 kg
□ The size of the child's shoes is: ≈ 28.5

Figure 3. Static anthropometric measures, for 5th centil (P_5)

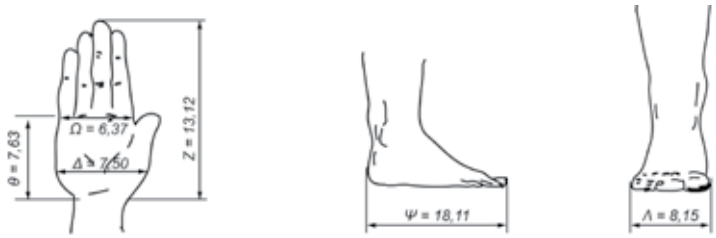
□ Static anthropometric measurements of the child's body in a standing position (Longitudinal measurements in cm, weight in kg)



□ Static anthropometric measurements of the child's body in a sitting position



□ Anthropometric measurements of the child's hand and foot



□ The child's weight is: Q = 13.35 kg
□ The size of the child's shoes is: ≈ 25.5

3.2. Results of dynamic anthropometric measurements

For the purposes of doing dynamic anthropometric measurements, a number of statistical data has been calculated and presented in corresponding tables ($X_{min.}$, $X_{max.}$, R, $\overline{x}$, $\overline{\Theta}$, σ^2, σ, $\varepsilon_{max.}$, σ_x k_v, k_A, k_E, P_5, P_{95}, P_{50}) (Table 5), while Table 6 shows the coefficients of the correlation among these measures. Figures 4, 5 and 6 present the dynamic anthropometric measurements of pre-school children for the 5th, 50th and 95th percentile.

Table 5. Statistical data of the dynamic anthropometric measurements of pre-school children (all three age groups, n=65 children)

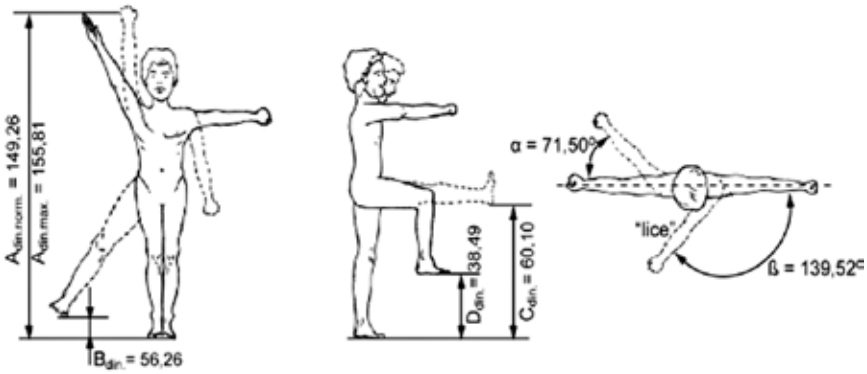
Serial number in the group	Serial number in the sub-group	Anthropometric dynamic measurements of the child's body in a standing position (lengths are expressed in **cm**, angles in ^{0})							Anthropometric dynamic measurements of the child's body in a sitting position (lengths are expressed in **cm**, angles in ^{0})						Anthropometric dynamic measurements of the hand and the foot	
		Normal height of reach by hand	Maximum height of reach by hand	Maximum height of lateral reach by foot	Maximum height of raising the outstretched leg	Maximum height of raising a leg bent in the knee	Maximum angle of rotating the arm (backward)	Maximum angle of rotating the arm (forwards)	Normal height of reach by hand	Maximum height of reach by hand	Maxi. forward reach by hand	Maxi. lateral reach by hand	Max. forward reach of foot, leg outstretched	Maximum lateral reach by foot	Maximum diameter of bar, for hand-grip	Maximum angle of foot rotation
		$A_{din.nor.}$	$A_{din.max.}$	$B_{din.}$	$C_{din.}$	$D_{din.}$	$\alpha_{din.}$	$\beta_{din.}$	$E_{din.nor.}$	$E_{din.max}$	$G_{din.}$	$L_{din.}$	$S_{din.}$	$X_{din.}$	**Ø** (cm)	ψ (^{0})
1.	ΣX_i	8437.50	8866.00	2325.00	2750.00	1875.00	3080.00	7630.00	5007.50	5449.50	4968.00	4087.00	4385.50	2708.00	250.20	3585.00
2.	X_{min}	111.00	117.00	18.00	16.00	16.00	30.00	65.00	64.00	70.00	58.00	43.00	53.00	28.00	2.50	35.00
3.	X_{max}	159.00	168.00	63.00	78.00	43.00	90.00	150.00	95.00	104.00	106.00	83.00	88.00	58.00	5.30	85.00
4.	**R**	48.00	51.00	45.00	62.00	27.00	60.00	85.00	31.00	34.00	48.00	40.00	35.00	30.00	2.80	50.00
5.	$\bar{x}$	129.81	136.40	35.77	42.31	28.85	47.38	117.38	77.04	83.84	76.43	62.88	67.47	41.66	3.85	55.15
6.	$\bar{\theta}$	10.15	10.06	10.39	8.07	4.80	10.69	10.00	6.16	6.71	8.60	6.40	5.54	7.36	0.54	11.11
7.	σ^2	140.69	140.15	156.18	117.66	34.58	216.24	182.21	55.86	62.58	109.26	65.31	45.12	67.76	0.42	168.75
8.	σ	11.86	11.84	12.50	10.85	5.88	14.70	13.50	7.47	7.91	10.45	8.08	6.72	8.23	0.65	12.99
9.	$\varepsilon_{max.}$	29.19	31.60	27.23	35.69	14.15	42.62	32.62	17.96	20.16	29.57	20.12	20.53	16.34	1.45	29.85
10.	σ_X	1.47	1.47	1.55	1.35	0.73	1.82	1.67	0.93	0.98	1.30	1.00	0.83	1.02	0.08	1.61
11.	k_V	0.09	0.09	0.35	0.26	0.20	0.31	0.11	0.10	0.09	0.14	0.13	0.10	0.20	0.17	0.24
12.	k_A	0.40	0.46	0.53	0.34	0.35	1.41	-0.77	0.62	0.54	0.42	0.12	0.46	0.19	0.25	0.70
13.	k_E	-1.38	-1.05	-1.21	-2.82	-1.35	-1.48	-2.58	-1.08	-1.13	-1.47	-2.30	-1.03	-2.00	-1.73	-2.11
14.	P_5	110.36	116.99	15.27	24.52	19.20	23.27	95.25	64.78	70.87	59.29	49.62	56.45	28.16	2.79	33.85
15.	P_{50}	129.81	136.40	35.77	42.31	28.85	47.38	117.38	77.04	83.84	76.43	62.88	67.47	41.66	3.85	55.15
16.	P_{95}	149.26	155.81	56.26	60.10	38.49	71.50	139.52	89.30	96.81	93.57	76.13	78.49	55.16	4.91	76.46

Table 6. Correlation coefficients (r) of dynamic anthropometric measurements of pre-school children (all three age groups, n=65-children)

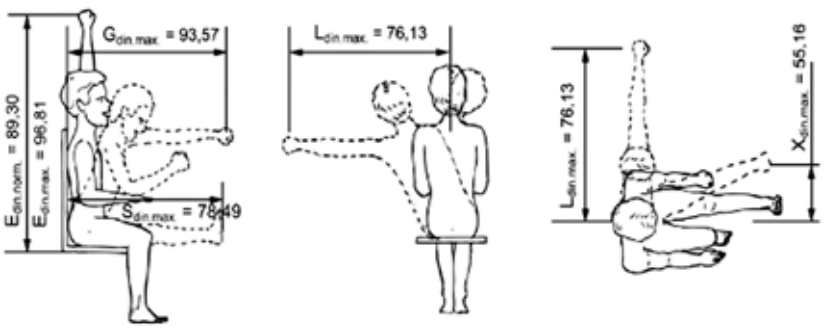
Serial number in the group		Anthropometric dynamic measurements of the child's body in a standing position (lengths are expressed in **cm**, angles in ^{0})							Anthropometric dynamic measurements of the child's body in a sitting position (lengths are expressed in **cm**, angles in ^{0})							Anthropometric dynamic measurements of the hand and the foot	
	Serial number in the sub-group	Normal height of reach by hand	Maximum height of reach by hand	Maximum height of lateral reach by foot	Maximum height of raising the outstretched leg	Maximum height of raising a leg bent in the knee	Max. (backward) rotation angle for arm	Max. (forward) rotation angle for arm	Maximum height of reach by hand	Normal height of reach by hand	Maximum forward reach by hand	Maximum lateral reach by hand	Max. forward reach of foot with outstretched leg	Maximum lateral reach by foot	Maximum diameter of bar, for hand-grip	Maximum angle of foot rotation
		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
		Serial number and symbol of dynamic anthropometric measurements														
		$A_{din.nor}$	$A_{din.ma}$	$B_{din.}$	$C_{din.}$	$D_{din.}$	$\alpha_{din.}$	$\beta_{din.}$	$E_{din.nor.}$	$E_{din.ma}$	$G_{din.}$	$L_{din.}$	$S_{din.}$	$X_{din.}$	Ø	ψ
1.	$A_{din.nor.}$	1.00	0.98	0.48	0.20	0.37	-0.12	0.24	0.87	0.91	0.54	0.39	0.70	0.76	0.55	0.17
2.	$A_{din.max.}$		1.00	0.50	0.22	0.41	-0.07	0.28	0.86	0.91	0.55	0.40	0.72	0.76	0.56	0.17
3.	$B_{din.}$			1.00	0.24	0.37	-0.01	0.28	0.48	0.44	0.15	0.04	0.28	0.34	0.35	-0.06
4.	$C_{din.}$				1.00	0.37	0.11	0.19	0.18	0.20	0.27	0.02	0.02	0.23	0.11	0.13
5.	$D_{din.}$					1.00	-0.05	0.20	0.47	0.49	0.23	0.19	0.12	0.39	0.03	-0.08
6.	$\alpha_{din.}$						1.00	0.24	-0.17	-0.11	0.08	0.03	-0.16	0.13	-0.05	0.09
7.	$\beta_{din.}$							1.00	0.27	0.21	0.03	-0.08	0.08	0.31	0.07	0.08
8.	$E_{din.nor.}$								1.00	0.93	0.41	0.36	0.56	0.70	0.39	0.15
9.	$E_{din.max.}$									1.00	0.48	0.35	0.61	0.75	0.47	0.15
10.	$G_{din.}$										1.00	0.54	0.57	0.33	0.15	0.16
11.	$L_{din.}$											1.00	0.40	0.26	0.16	0.18
12.	$S_{din.}$												1.00	0.51	0.37	0.13
13.	$X_{din.}$													1.00	0.43	0.19
14.	**Ø**														1.00	0.10
15.	**ψ**															1.00

Figure 4. Dynamic anthropometric measurements of reach and rotation angles for 95th centil (P_{95})

□ Dynamic anthropometric measurements of the child's reach in the standing position of the body



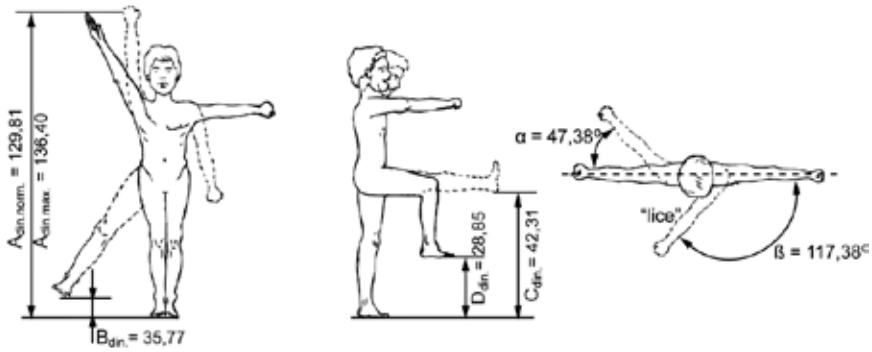
□ Dynamic anthropometric measurements of the child's reach in the sitting position of the body



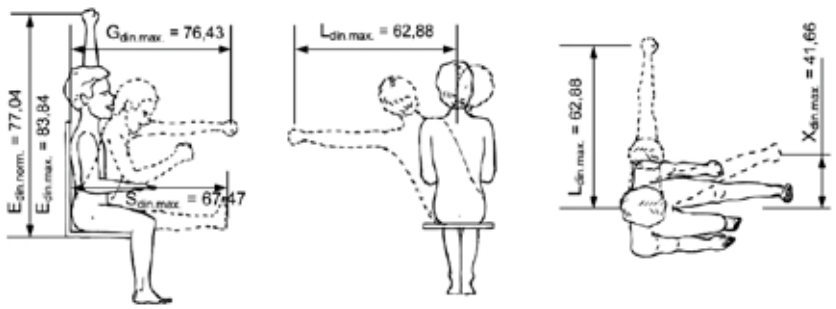
□ Dynamic anthropometric measurements of the child's hand and foot

Figure 5. Dynamic anthropometric measurements of reach and rotation angles for 50th centil (P_{50})

□ Dynamic anthropometric measurements of the child's reach in the standing position of the body



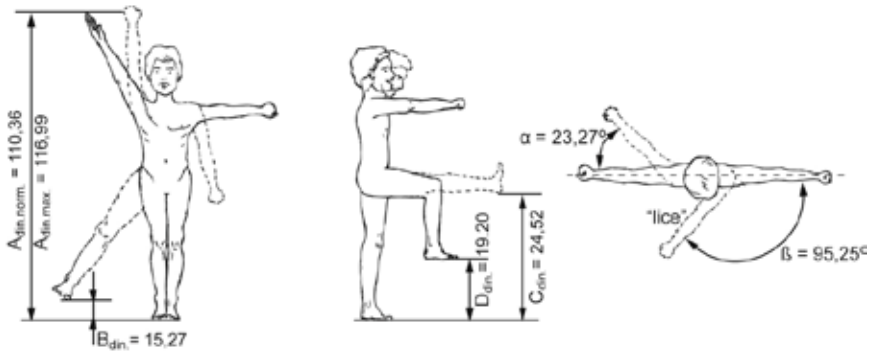
□ Dynamic anthropometric measurements of the child's reach in the sitting position of the body



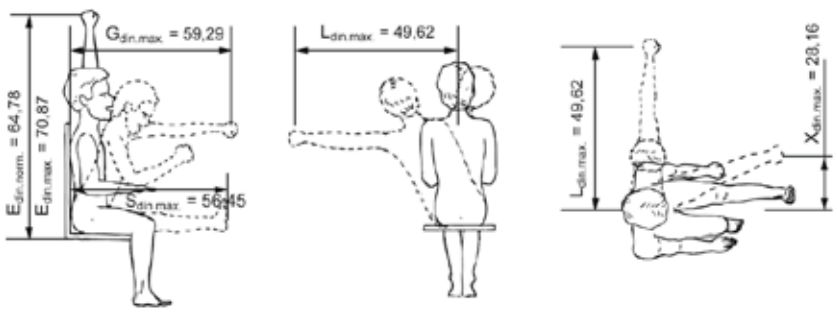
□ Dynamic anthropometric measurements of the child's hand and foot

Figure 6. Dynamic anthropometric measurements of reach and rotation angles for 5th centil (P_5)

□ Dynamic anthropometric measurements of the child's reach in the standing position of the body



□ Dynamic anthropometric measurements of the child's reach in the sitting position of the body



□ Dynamic anthropometric measurements of the child's hand and foot:

4. Conclusion

Anthropometric static and dynamic measurements of pre-school children obtained by the method of direct measurement presented in this paper are useful in many different ways:

- For the first time in Serbia, such measurements were used to define anthropometric measurements of pre-school children, and this very fact emphasises the significance of this research.
- The ergonomic design of the elements of playground equipment is based on the direct measurement of static and dynamic anthropometric measurements of pre-school children.
- These playgrounds possess all the prerequisites to satisfy users (children, their parents and educators), while the safety and health of the children playing with ergonomically designed equipment is improved at the same time.
- The static and dynamic anthropometric measurements presented in this paper can also be used by medical institutions that monitor the growth and development of pre-school children.
- This research can be extended to other parts of Serbia, creating an opportunity for the Standardisation Institute to initiate introduction of standards for children's clothes, footwear, toys and similar items.

Dr. Savko Jekić, dr. Miroljub Grozdanović, dr. Dragan Golubović, dr. Evica Stojiljković

Načrtovanje ergonomsko oblikovanega pohištva za otroke

Igrača je pomemben vzgojno-izobraževalni pripomoček. O velikem pomenu igrače za psiho-fizični razvoj otroka lahko navedemo misel slavnega raziskovalca E. Seguena, da se otroci ne morejo iz knjig naučiti tistega, kar jim lahko nudijo igrače... Če poveste, s kakšnimi igračami se danes igrajo vaši otroci, je mogoče napovedati, kakšni ljudje bodo postali jutri.

Ni druge stvari na svetu, ki bi bila tako privlačna za otroke in bi tako izpolnila njihov čustveni svet, kot ga lahko igrača. Z njeno pomočjo otroci razvijajo svoje čute in mišice, učijo se družabnosti. Igrače prispevajo k razvoju inteligence in pomagajo pri učenju. Razvijajo ustvarjalnega duha pri otrocih in prispevajo k razvoju komunikacijskih veščin.

Sodobne igrače morajo biti ergonomsko zasnovane, da se prilagodijo obliki otroške roke, telesnim dimenzijam otroka (višini, teži), prilagojene morajo biti njegovi trenutni razvojni stopnji, kar se mora odražati v njihovi velikosti in zahtevnosti, tako da se otrok lahko z njimi igra po svojih zamislih in brez tveganja, pri tem pa se mora toliko potruditi, da bo to pozitivno učinkovalo na njegov intelektualni razvoj.

Ergonomsko oblikovano pohištvo za otroke zajema dve glavni področji: prilagajanje opreme (pohištva za otroke) in okolja (igrišč, prostorov, športnih dvoran) otrokom (njihovemu odraščanju).

V Srbiji še vedno niso izdelani nacionalni antropometrični standardi, ker je bilo treba organizirati in izvajati meritve na velikem številu vzorcev, jih spremljati več let (najmanj dve desetletji in več), kar pa zahteva velika finančna sredstva. Za svoje potrebe so bili proizvajalci pohištva za otroke prisiljeni uporabiti tuje antropometrične standarde, ki pa jih je bilo treba prilagoditi, saj zaradi antropometričnih razlik niso vedno neposredno uporabni.

Glede na to, da v Srbiji doslej še niso izvajali nobenih nacionalnih antropometričnih meritev prebivalstva (niti predšolskih otrok), to delo zdaj predstavlja edini veljavni dokument te vrste. Namen tega prispevka je predstaviti rezultate statičnih in dinamičnih antropometričnih meritev dimenzij predšolskih otrok iz osrednje Srbije.

Statične in dinamične antropometrične meritve predšolskih otrok smo izvajali v vrtcu Poletarac v Čačku. Meritve so izvedene na vzorcu 65-ih otrok, in sicer: mlajših (17), srednjih (22) in starejših – predšolskih otrok (26). Rezultati zahtevanih parametrov so predstavljeni v obliki tabele.

Za statične antropometrične meritve je bilo uporabljenih: 12 izmer v stoječem, 11 v sedečem položaju, 7 izmer roke, noge in glave, ki skupaj s težo in številko čevljev otroka tvori seznam 32-ih podatkov. Za dinamične antropometrične meritve telesa otrok je izbranih 15 izmer, in sicer 7 v stoječem, 6 v sedečem položaju in 2 izmeri rok in nog (stopal).

Pri načrtovanju pohištva za otroke statične ergonomsko-antropometrične izmere predšolskih otrok lahko zadoščajo, vendar so zelo pomembne tudi dinamične. Usklajevanje izmer pohištva za otroke in celotnega delovnega mesta, tj. prostora za igranje otrok (otroška igrišča, igralnice), s statičnimi in dinamičnimi antropometričnimi izmerami otrok lahko močno izboljšajo varnost, funkcionalnost, udobje, pa tudi zadovoljstvo uporabnikov: otrok, njihovih staršev in vzgojiteljev.

V tabeli smo prikazali najpomembnejše statične in dinamične izmere otrok, ki so nujno potrebne za ergonomsko oblikovanje pohištva za otroke, otroških igrišč in varnostne cone okoli pohištva za otroke. Izračunali smo tudi potrebne korelacijske koeficiente med 32-imi izmerami otroškega telesa.

Varnost otrok pri uporabi pohištva je odvisna predvsem od inženirskega znanja in izkušenj pri izbiri materialov, pa tudi od preračuna dimenzij prečnega prereza nosilnih in veznih elementov (konstrukcijske celote). Pri uporabi teh antropometričnih rezultatov in znanja iz uporabne umetnosti in psihologije je v celoti zagotovljeno zadovoljstvo in varnost otrok – uporabnikov tega pohištva med igro in po njej.

Antropometrične statične in dinamične izmere predšolskih otrok, dobljene z neposrednimi meritvami, o katerih poročamo, so pomembne, ker:

- *so bile v Srbiji prvič izvedene antropometrične meritve in opravljena statistična analiza rezultatov;*

- *so oblikovalci opreme za otroke na osnovi teh podatkov lahko načrtovali otroško pohištvo, ki bo zagotovo zadovoljuje uporabnike (otroke, njihove starše in vzgojitelje) in močno izboljšuje varnost in zdravje otrok med igro na ergonomsko oblikovanem pohištvu in opremi;*
- *dobljene rezultate antropometrije predšolskih otrok lahko uporabljajo tudi medicinske ustanove za spremljanje rasti in razvoja otrok v predšolskem obdobju;*
- *rezultate te študije lahko uporablja tudi inštitut za standardizacijo pri uvajanju standardov za otroško opremo, namenjeno otrokom določene starosti.*

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Dr. Savko Jekić (1955), Mech. Engineering ASA-CO d.o.o. Company.
Address: Stara pruga bb, 32212 Preljina, Čačak, Serbia; Phone: (+381) 063 622 343
E-mail: asa_co@open.telekom.rs

Dr. Miroljub Grozdanović (1947), full professor at the University of Niš, the Faculty of Occupational Safety in Niš.
Address: Čarnojevića 10a, 18000 Niš, Serbia; Phone: (+381) 063 406 248
E-mail: miroljub.grozdanovic@znrfak.ni.ac.rs

Dr. Dragan Golubović (1947), full professor at the University of Kragujevac, the Technical Faculty in Čačak.
Address: Svetog Save 65, 32000 Čačak, Serbia; Phone: (+381) 063 827 52 24
E-mail: golubd@tfc.kg.ac.rs

Dr. Evica Stojiljković (1976), assistant professor at the University of Niš, the Faculty of Occupational Safety in Niš.
Address: Čarnojevića 10a, 18000 Niš, Serbia; Phone: (+381) 069 148 70 31
E-mail: evica.stojiljkovic@znrfak.ni.ac.rs