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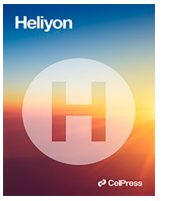

Research article

Comparison of anthropometric dimensions of preschool children and chairs in kindergartens in North Macedonia, Bulgaria and Croatia

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ABSTRACT

The mismatch the kindergarten furniture dimensions with the children's anthropometric, as well as the design of non-ergonomic kindergarten furniture, potentially affects inappropriate body positions, and thus potential low back pain when sitting in later human development. The aim of this study was to examine the anthropometric measurements of preschool children and compare them with the dimensions of the preschool chairs in kindergartens in North Macedonia, Bulgaria and Croatia, in order to perceive the current situation and suggest improving for kindergarten furniture design. 848 children in 27 kindergartens participated in the research. A total of 36 types of chairs was found and measured. Children's upper leg length, popliteal height and hip width were measured and compared with the three main chair functional dimensions according to the EN 1729–1:2015. The main value of this research is the comparative data obtained, which indicates that there is a significant difference between preschool chairs and children's dimensions in some groups, but that the results cannot be generalized since they refer to a specific kindergarten population. In reality, it will never be possible to satisfy all dimensions of children and furniture, primarily due to the existence of (too) tall and (too) short children in certain groups. A further recommendation is to introduce a systematic measurement of preschool children at the beginning of the new school year and thus harmonize their anthropometric dimensions with the furniture.

1. Introduction

Preschool institutions, known as nurseries or kindergartens, are educational institutions where the upbringing and education process of children takes place, usually between the ages of 9 months and 7 years, before starting elementary school. During this period, children experience the greatest physical cognitive and mental changes, so attention should be paid to the design and furnishing of this type of facilities, both from the educational, architectural, organizational and pedagogical aspects, as well as from the design aspect of user-friendly furniture used in the interior environment [1]. While designing furniture and equipment for educational institutions, the question of their quality and design values are approached as the least valuable for discussion [2]. Furniture is usually observed as a functional object in a facility, so for example a chair is seen as a product for sitting, a table is a product that enables work and dining, etc., while multifunctional features are omitted. Children's furniture is designed mostly as copies of the already existing

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furniture used by adults, with reduced dimensions. This approach does not support the healthy and comprehensive psychophysical and cognitive development of children [3,4], and very little care is taken to develop the child's health and the need for play and imagination through appropriate furniture design [5,6].

Furniture in kindergartens is an integral factor in the general conditions of preschool facilities [7]. The shape and size of furniture affect the psycho-physical development and sitting habits of children [8,9]. The mismatch of furniture from anthropometric and ergonomic aspects potentially affects deformations in the later development of the child [10–12]. Inadequate dimensioning of furniture leads to an incorrect sitting position, which causes musculoskeletal discomfort and back pain (MSD/BP) [13,14] as well as fatigue during prolonged sitting, which is current topic for numerous researchers over the decades [15,16]. MSD/BP is a growing problem in many countries of the world and globally and affects almost 40% of children [17].

In addition to the correctly used chair measurements, the design of the chairs plays an important role in the sitting process. According to Refs. [18,19], when the body is actively sitting, it changes into many different positions. The problem of improper sitting also stems from inadequately dimensions of chairs and tables, which results in improper posture and fatigue of the sitter. It is considered that sitting in relation to furniture depends on four principles: 1. the need for lumbar support; 2. angle of inclination of the backrest; 3. chair height and 4. table height [20].

When designing an ergonomic chair, three dimensions are considered as the most important: the height of the seat, the seat depth, and the seat width. Most attention is given to the dimensioning of the seat height, but the seat depth is often overlooked. The problem occurs if the depth is too large for shorter people, so the front edge of the chair often presses on the bend of the internal knee flexion and creates pressure in the lower legs, which makes circulation in the legs difficult [21]. The most studies do not systematically investigate the subjective and objective effects of increasing and/or decreasing seat depth [22]. Along with anthropometry, which should be the main factor when sizing chairs, an important condition is a purpose for which the chair is produced (for dining, for work, for rest …). A methodology for assessing the suitability of school furniture dimensions is proposed [23]. Unfortunately, comparisons of the appropriateness of furniture dimensions and children in kindergartens are rarely or almost never made.

The aim of this research was to investigate and compare the anthropometric measurements of preschool children with the main functional dimensions of chairs in kindergartens of North Macedonia (Skopje), Bulgaria (Sofia) and Croatia (Zagreb), in order to perceive the current situation, observe similarities and differences in the way of furnishing and furniture design, and provide suggestions for improving the ergonomics of furniture (chair) design regarding to the chair dimensions in the observed countries.

2. Materials and methods

2.1. Polygons for anthropometric and chairs measurements

The research was conducted in three countries and their capital cities: (I) Skopje, Republic of North Macedonia; (II) Sofia, Republic of Bulgaria; and (III) Zagreb, Republic of Croatia in the period from January 2017 to January 2020.

In each city, measurements were made in 27 kindergartens where the children's anthropometric variables and chair dimensions were measured (Table 1).

2.2. Participants in anthropometric measurements - preschool children

The preschool children from the locations I, II, and III were selected and measured through five different groups, divided by age: (a) the largest nursery group (children up to 2 years of age), (b) the small group (3–4 years), (c) the medium group (4–5 years), (d) the large group (5–6 years) and (e) children in the preschool group (children 6–7 years).

The youngest child at the time of the measurement was 2 years and 2 months old and the oldest one was 7 years and 6 months old.

2.3. Anthropometric variables measured on preschool children

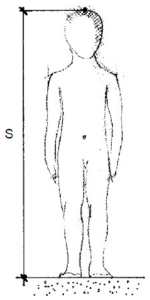
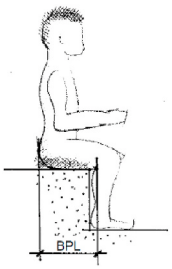
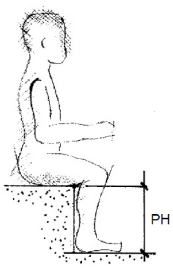
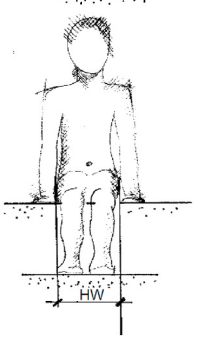
Four main body variables were measured on preschool children, according to Ref. [24] (Table 2). Three variables were measured in the child's sitting position. The children were sitting on the type of chair that was found in each observed kindergarten.

The variables were recorded for each child separately and written in the special form. During the measurement process, the children were dressed in similar clothes: T-shirt and cotton pants, without shoes. The time of measurement was from 9 a.m. to 12 p.m. from Monday to Friday.

Table 1
The number of kindergartens included in the measurements in each location/city/country.

Location	City, country	Number of observed kindergartens
I	Skopje, North Macedonia	8
II	Sofia, Bulgaria	7
III	Zagreb, Croatia	12
I + II + III	Total number of kindergartens	27

Table 2
Four main anthropometric variables included in the research. Author's drawings.

Position of the measured variable	Variable	Variable description
	S - Stature	Vertical distance from the vertex to the substrate on which the feet are placed.
	BPL - Upper leg length, buttock-popliteal length, seated)	Horizontal distance from the buttock to the inner knee brace in a seated position.
	PH - Popliteal height, seated	Vertical distance from the buttock to the inner knee flexion, measured in an upright posture, with the elbow and foreleg positioned at right angle. Feet completely touch the floor.
	HW - Hip width, maximum when seated	The horizontal distance between the two furthest points left and right of the hips and buttocks, if the respondent is in a sitting position.

2.4. Functional dimensions measured on chairs

Measurements of the functional dimensions of the chairs were carried out on all types of chairs found in the observed kindergartens. The chairs were in everyday use. Three main functional dimensions of the chair were measured according to Ref. [25] (Table 3). Measurements were made with a metal measuring tape with millimeter markings.

Table 3
Functional dimensions measured on chairs, symbols are according to Ref. [25].

Symbol	Description of the measured functional dimension of the chair
h8	height of seat
b3	seat width
t4	effective depth of seat

2.5. Ethical approval and permission for conducting the research

Approval and confirmation that the research is in accordance with the principles and rules of the Code of Ethics [26] were given by the University of Zagreb Ethics Committee. In addition, permissions to enter kindergartens and conduct research were obtained in all three locations/cities from the competent ministries, individual state or city offices, kindergarten principals, and parents/guardians whose children participated in the research. Informed consent was obtained from all research participants (principals, teachers, parents/guardians). All participants were informed about the aim of the study and possible withdrawal at any stage.

2.6. Statistical data processing

Chi-Square Test was used for comparison of data between and among categories (h8, b3, t4), and if the conditions for using Chi-square are not met, it was substituted with Fisher's Exact Test. Differences between two independent sets of numerical data (h8, b3, t4) were tested with nonparametric Mann-Whitney *U* Test, while differences between more than two independent sets of numerical data were tested with nonparametric Kruskal-Wallis Test and Conover post-hoc Test as distributions didn't follow Gaussian normal distribution (tested with Shapiro-Wilk Test). Significant level was defined as $p < 0.05$, where all P values were two-tailed as it is standard and differences were measured in both ways in distributions.

Statistical analysis was done with either MedCalc (release 19.1.3) or IBM SPSS Statistics (release 24.0.0.0) software tools, with statistical significance defined as $\alpha = 0.05$, where all P values were two-tailed.

3. Results

3.1. Results of children anthropometric measurements

A total of 848 preschool children participated in anthropometric measurements, of which 446 were boys and 406 were girls. (Table 4).

There is significant difference (Chi-Square Test, $P < 0.001$) found in age between children measured in different cities. In Skopje there is higher percentage of younger children comparing to the Sofia and Zagreb, where is higher percentage of the older ones. In the research, 8.8% of extreme data is left out.

In most age groups, popliteal height on average is significantly higher in children from Skopje Skopje Results are presented in Fig. 1

Table 4
Distribution of measured children by age and groups.

Location I	Skopje						
age/group	(a) 2–3 years	(b) 3–4 years	(c) 4–5 years	(d) 5–6 years	(e) 6–7 years*	total	Total per gender
Boys	17	23	47	59	/	146	51.9%
Girls	15	16	50	54	/	135	49.1%
Total per groups (N)	32	39	97	113	/	281	100%
Location II	**Sofia**						
years/group	(a) 2–3 years	(b) 3–4 years	(c) 4–5 years	(d) 5–6 years	(e) 6-7+ years	total	Total per gender
Boy	2	25	33	40	45	145	50.7%
Girl	/	27	43	25	46	141	49.3%
Total per groups (N)	2	52	76	65	91	286	100%
Location III	**Zagreb**						
years/group	(a) 2–3 years	(b) 3–4 years	(c) 4–5 years	(d) 5–6 years	(e) 6-7+ years	total	Total per gender
Boy	12	34	36	36	37	155	55.1%
Girl	12	28	31	28	27	126	44.9%
Total per groups (N)	24	62	67	64	64	281	100%
Total number of participants in Locations I002C II and III							
	(a) 2–3 years	**(b) 3–4 years**	**(c) 4–5 years**	**(d) 5–6 years**	**(e) 6-7+ years**	**Total number/per gender**	**Total percentage/per gender**
Boy	31	82	116	135	82	446	52.6%
Girl	27	71	124	107	73	402	47.4%
Total/per groups	58	153	240	242	155	848	100%
Percentage/per groups	6.8%	18.1%	28.3%	28.5%	18.3%	100%	

Note*: In the Republic Macedonia since 2008, according to the Law on Primary Education, children from 6 to 7 years enter the education process of primary schools, not the preschool process as before [27].

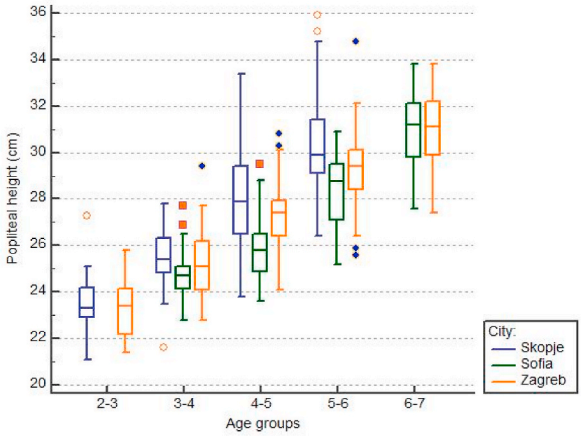


Fig. 1. Results of measured popliteal height (PH).

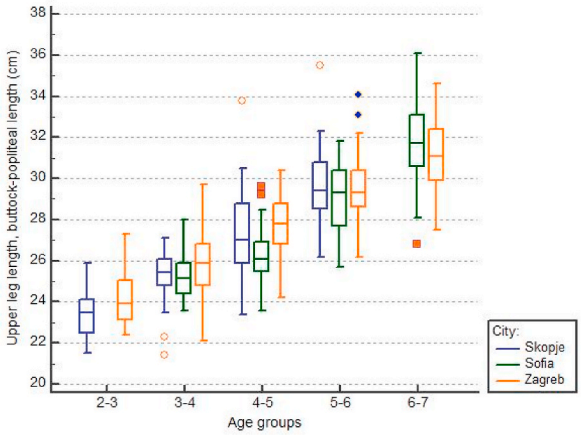


Fig. 2. Results of measured buttock - popliteal length (BPL).

using box and whisker plot with median (IQR), where in group of age 2–3 and 6–7 is used Mann-Whitney *U* Test, P = 0.75, and from other groups from 3 to 4 age, 4–5 age, 5–6 age is used Kruskal-Wallis Test, P = 0.02 (3–4 age group), P < 0.001 (4–5 and 5–6 age groups) (Fig. 1). Children in Zagreb have a significantly longer buttock-popliteal length. Results are presented in Fig. 2 using box and whisker plot with median (IQR), where in group of age 2–3 and 6–7 is used Mann-Whitney *U* Test, P = 0.10 (2–3 age group), P = 0.14

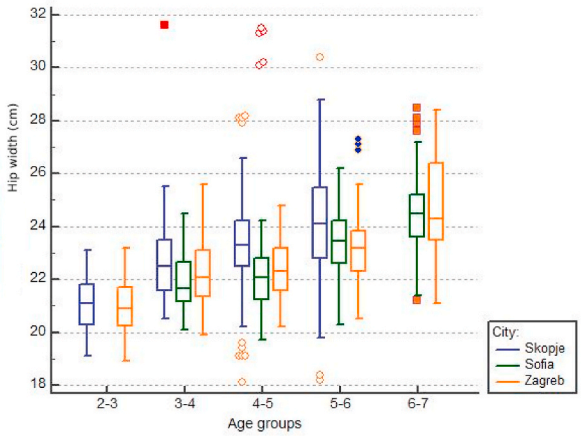


Fig. 3. Results of measured hip width (HW), while sitting.

Table 5
The results of the functional dimensions of measured chairs.

(I) Skopje					(II) Sofia					(III) Zagreb				
type of chair	seat height (h8)	seat width (b3)	seat depth (t4)	%	type of chair	seat height (h8)	seat width (b3)	seat depth (t4)	%	type of chair	seat height (h8)	seat width (b3)	seat depth (t4)	%
A	35	30	30	31% of examined chairs	T	30	31	25	22% of examined chairs	I	34	31.8	34	47% of examined chairs
B	27	30	28	among investigated cities	U	35	29	28,5	among investigated cities	I1	25	25.5	26.5	among investigated cities
C	29	33	30		U1	29	27	26		K	29	29	27	
D	29	30	30		V	30,5	24	29		L	27	30	26.6	
D1	34	33.5	33		W	37	60, 120	32		M	32.5	37.5	32.5	
E	34	33	33		X	28,5	28	29		N	35	32	30	
										N1	33	27	26	
										N2	31	28	26	
										N3	25	27	30	
F	27/30	30	30		Y	32	28	23		O	35	30	25.2	
G	35.5	43	38		Z	32	28	29		P	34	36	33	
										P1	30	32	30	
										P2	25	28	26	
H	24	30	25							R	35	34	29	
										R1	34	34	34	
										R2	30	28	27	
J	31	35	40							S	22.5	29	25	
J1	32	73	35											

All dimensions are in cm.

(6–7 age group), and from other groups from 3 to 6 is used Kruskal-Wallis Test, P = 0.02 (3–4 age group), P < 0.001 (4–5 age group); P = 0.23 (5–6 age group) (Fig. 2). The width of the buttocks is significantly highest among preschool children from Skopje Results are presented in Fig. 3 using box and whisker plot with median (IQR), where in group of age 2–3 and 6–7 is used Mann-Whitney *U* Test, P = 0.71 (2–3 age group) and P = 0.57 (6–7 age group), and from other groups from 3 to 4 age, 4–5 age, 5–6 age is used Kruskal-Wallis Test, P = 0.009 (3–4 age group), P < 0.001 (4–5 age group); P = 0.002 (5–6 age group) (Fig. 3). This means that the preschool children in Skopje seem to be taller than the preschool children from Sofia and Zagreb.

3.2. Results of chair measurements

A total of 36 types of chairs have been measured, 11 types in Skopje, 8 types in Sofia and 17 types of chairs in Zagreb, marked with capital letters from A to Z. Table 5 shows the data of three measured variables of all types of chairs in observed kindergartens.

4. Discussion

The obtained results of the anthropometric dimensions of children are compared with the dimensions of the chair, according to: PH (popliteal height) with h8 (seat height), HW (hip width) with b3 (seat width) and BPL (buttock-popliteal length) with t4 (seat depth).

4.1. Comparison of popliteal height (PH) with seat height (h8), while sitting

The height of chairs (h8) was compared with the average popliteal height (PH) of age groups within particular city, with the tolerance of ±10 mm according to Ref. [25]. It is relatively small percentage (8.3%) of the chairs that fits the youngest group of children, but there was very small number of children (in Sofia very few) in the youngest group in the kindergartens. Chairs, for the most part, fit children from 5 years old and older (66.7%) (Table 6).

According to Ref. [25] the preschool chairs are divided into size marks 0, 1, 2, and 3. By comparing the popliteal height in the sitting position (PH) with the seat height (h8), the results indicate that the height of seat of the size mark 1 would not suit children aged between 2 and 3 years (group a). The height of the seat size mark 0, particularly 23 cm of height, would be more suitable for the group (a). In Sofia, children from 5 to 6 years old (group d) do not fit into the size mark 2 of the chair seating height (h8). The group (d) in Sofia would prefer a height of chairs between size mark 1 and 2, more precisely 29 cm of height. Other age groups of children in all three locations may use the height of the chairs as determined by the standard (Table 7).

It is evident that for children from 2 to 3 years old, height of seat with size mark 1 would not fit their age, and the height seat size mark 0 would be more appropriate. This study shows that the appropriate chairs for children at this age would be 23 cm of height. Children from 5 to 6 years old in Sofia do not enter into the height seat size mark 2, they would prefer a height of seat between size mark 1 and 2, more precisely 29 cm of height. Other age groups of children may use the height of the seat as determined by Ref. [25]. For children from 2 to 3 years the most suitable are chairs with size mark 0, for children from 3 to 4 years and 4–5 years suitable are chairs with size mark 1 and 2, from 5 to 6 size mark 2 and 3, and from 6 to 7 size mark 3 (Fig. 4).

Table 6
The result of the harmonized number of chairs whose height of seats (h8) corresponds to the anthropometric variable PH in children in all three locations.

location	group/suitability	number of measured chairs			P[1]	N (%)
		I	II	III		
		Skopje	Sofia	Zagreb		total
Total measured chairs per city		11	8	17		36
(a)	Age from 2 till 3					
suitability	fit	0	no data	3	0.26	3
	not fit	11		14		33
(b)	Age from 3 till 4					
suitability	fit	3	no data	4	>0.99	7
	not fit	8		13		29
(c)	Age from 4 till 5					
suitability	fit	4	no data	2	0.17	6
	not fit	7		15		30
(d)	Age from 5 till 6					
suitability	fit	4	4	4	0.44	12
	not fit	7	4	13		24
(e)	Age from 6 till 7					
suitability	fit	3	5	4	0.18	12
	not fit	8	3	13		24
(f)	Age from 7 till 8					
suitability	fit	3	1	8	0.25	12
	not fit	8	7	9		24

[a] [1] Fisher's Exact Test.

Table 7
Comparison of PH and HW while sitting, with h8 and b3 according to Ref. [25].

Anthropometrical variables	Size mark	Skopje	EN 1729-1 2015	Sofia	EN 1729-1 2015	Zagreb	EN 1729-1 2015
(a) children aged 2–3 years							
S	1	97.2 (94.6–99.5)	93–116	/	/	96.2 (91.9–98.9)	93–116
PH	1	23.3 (22.9–24.2)	25–28	/	/	23.4 (22.1–24.2)	25–28
HW	1	21.1 (20.3–21.8)	no data	/	/	20.9 (20.2–21.8)	no data
h8	1	**23**	26	/	/	**23**	26
b3	1	21	24	/	/	21	24
(b) children aged 3–4 years							
S	1	103.5 (100.4–106.5)	93–116	101.5 (99.6–103.7)	93–116	101.5 (100.4–104.2)	93–116
PH	1	25.4 (24.8–26.3)	25–28	24.7 (24.1–25.1)	25–28	25.1 (24.1–26.2)	25–28
HW	1	22.5 (21.6–23.5)	no data	21.7 (21.1–22.7)	no data	22.1 (21.3–23.1)	no data
h8	1	25	26	25	26	25	26
b3	1	22	24	22	24	22	24
(c) children aged 4–5 years							
S	1 2	108.4 (105.6–112.3)	93–116 108–121	105.2 (102.4–108.4)	93–116 108–121	109.1 (106.1–111.5)	93-116 108-121
PH	1	27.9 (26.5–29.4)	25–28	25.8 (24.9–26.6)	25–28	27.4 (26.3–28.0)	25–28
HB	1	23.3 (22.5–24.2)	no data	22.1 (21.2–22.8)	no data	22.3 (21.6–23.2)	no data
h8	1	28	26	26	26	27	26
b3	1	23	24	22	24	22	24
(d) children aged 5–6 years							
S	2	115.7 (113.3–119.8)	108–121	113.7 (111.4–117.2)	108–121	114.5 (110.1–117.6)	108–121
PH Popliteal range	2	29.9 (29.1–31.5)	28–31.5	28.8 (27.1–29.5)	28–31.5	29.4 (28.4–30.1)	28–31.5
HW	2	24.1 (22.8–25.5)	no data	23.5 (22.6–24.2)	no data	23.2 (22.3–23.9)	no data
h8	2	30	31	**29**	31	30	31
b3	2	24	28	24	28	24	28
(e) children aged 6–7 years							
S	3	/	/	122.4 (119.3–125.1)	119–142	122.4 (118.1–125.2)	119–142
PH	3	/	/	31.2 (29.8–32.2)	31,5–35,5	31.1 (29.9–32.2)	31,5–35,5
HW	3	/	/	24.5 (23.6–25.2)	30	24.3 (23.5–26.4)	30
h8	3	/	/	31	no data	31	no data
b3	3	/	/	25	32	24	32

All dimensions are in cm.

4.2. Comparison of hip width (HW) with seat width (b3), while sitting

The seat width (b3), when compared to the anthropometric variable hip width (HW), indicates that there are no deviations (Table 7).

4.3. Comparison of buttock-popliteal length (BPL) with seat depth (t4), while sitting

According to Ref. [25], effective depth of seat (t4) is not given for the size mark 0, 1 and 2, while for size mark 3 it is 30 cm. Based on the anthropometric data obtained from this study, as well from the known literature, recommendations and suggestions on how effective depth of seat should be are presented in Table 8.

By reviewing the world literature and previous research, the data related to the mismatch of furniture dimensions with the anthropometric variables of school-age children are more pronounced compared to the data for preschool children. Rare but valuable research in kindergartens shows the same problems of mismatch of dimensions of kindergarten furniture and anthropometric dimensions of school children. For example, researchers in Turkey [28], Germany [29], and Indonesia [30] confirm observed inconsistencies, as was also confirmed in this study.

The results of the Turkey's study [28] indicate that for all types of furniture measured, some of the observed dimensions do not correspond to the anthropometric data of children. The authors point out that the tables are "very problematic" in terms of depth, somewhat less "problematic" in terms of width, while the chairs are "problematic" in terms of depth and height..

Research in Germany [29], indicates that it is possible to design fully functional furniture for children if the appropriate anthropometric data for children are known. This study points out that for the construction of optimally adapted chairs and tables, a detailed knowledge of body dimensions in the sitting position is necessary. To develop tables of optimal height, it is necessary to know the height of the seat and the height of the elbows above the seat.

Research conducted in West Jakarta [30] discusses the anthropometry and ergonomics of furniture design in the early childhood education system, observing children between 2 and 3 years of age of both sexes in a preschool classroom. Appropriate design, in addition to functional factors, also ensures health, safety, security and comfort for users during use and operation in preschool institutions. The goal network method was applied in the research. This method made it possible to determine the negative and positive

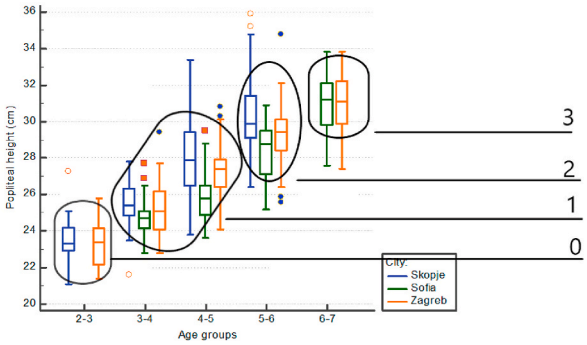


Fig. 4. Distribution of the measured dimensions of the popliteal height in the sitting position according to the age of the children and their grouping suggestions in accordance with the recommended size marks [25].

Table 8
Suggestions for effective depth of seat.

Parameters	(all measures in cm)		
	Skopje	Sofia	Zagreb
children aged between 2 and 3			
BPL (measured data)	23.5 (22.4–24.1)	/	23.9 (23.0–25.1)
t4 (recommendation)	21	/	21
children aged between 3 and 4			
BPL (measured data)	25.5 (24.8–26.1)	25.2 (24.4–25.9)	25.9 (24.8–26.8)
t4 (recommendation)	24	24	24
children aged between 4 and 5			
BPL (measured data)	27.0 (25.9–28.8)	26.1 (25.5–26.9)	27.8 (26.8–28.8)
t4 (recommendation)	24	24	24
children aged between 5 and 6			
BPL (measured data)	29.4 (28.5–30.8)	29.3 (27.7–30.4)	29.3 (28.6–30.4)
t4 (recommendation)	27	27	27
children aged between 6 and 7			
BPL (measured data)	/	31.7 (30.6–33.1)	31.1 (29.9–32.4)
t4 (recommendation)	/	29	29

characteristics of furniture for preschool institutions, which can definitely help the user to maximize the functionality of the furniture. also, it can help the industry in improving and developing new products.

4.3.1. General recommendations

After the presented data of the comparison of the observed variables, some general recommendations arising from the obtained results can be highlighted.

The height of the chairs should be in proportion to the height of the children's lower legs, i.e. not to be smaller or bigger. The backrest should include a part that will support the child's lumbar zone in order to keep the back in proper position. The angle between backrest and seat should be from 100° to 105°, in order to body can adopt comfort position, and then be able to lean forward easily. Also, the seat inclination should be 5° to 7°.

Generally speaking, although in reality it will never be possible to unify and satisfy all the variables (dimensions) of all children and furniture, mostly due to the existence of small groups of (too) tall and (too) short children in certain groups, we should strive for maximum matching of the observed dimensions of the chairs and the anthropometric variables of the children.

5. Conclusion

The process of seating preschool children is a complex and delicate topic. Kindergarten chairs should be designed to support the body, adapting especially to at least three important body position related to the daily upbringing and educational process of children:

- body position when the trunk and backs are leaning on the backrest (e.g. while listening to the teacher),
- body (trunk) position towards the worktop (e.g. while reading, playing or writing on the tabletop)
- body torsions (e.g. while discussion, rotation and looking around).

The strength of this research lies in the results that confirm that the stated anthropometric data cannot be generalized because they refer to a single observed kindergarten population, but they represent a good basis for further research and instructions for the

ergonomic design of chairs in kindergartens. The European standard are used over a large geographical area and each geographical location has different natural and social factors that influence the child development. It is therefore possible that some of the measures do not comply with the standard. Each country should, according to its specifics, conduct similar type of research and apply it for decision which chair size to use for each age group. EN 1729-1 should be respected, but each local environment should consider its specificities and, if possible, carry out limited measurements and, according to them, decide on the choice of chair sizes for certain ages of children.

From this study, we can conclude that the chairs in the observed kindergartens are not suitable for the age of some groups of preschool children, which potentially leads to improper physical and mental growth and development of the child. As a limitation of this research, it can be emphasized that it is not possible to combine and satisfy all the variables of all users and furniture through a statistical comparison, mainly due to the existence of smaller groups of (too) tall and (too) short children in certain groups, and therefore one should strive for maximum matching of the observed chair dimensions and children anthropometric variables. In order to improve this situation, multidisciplinary teams should be set up to work on education and awareness of appropriate body positions when sitting, and at the same time improve the design of preschool chairs. One of the improvement proposals would be to carry out anthropometric measurements (of the variables h8, b4, t4) of the children once a year and, depending on given dimensions, to choose the appropriate chair for the age of the child. Such anthropometric measurements have never been done in the countries where the research was conducted. It is also necessary to educate the staff who would perform these measurements, so that they know how to determine which chair height corresponds to the height of an individual child. The uneven growth and development of children of the same age does not allow the use of the same height chair, so it cannot be unified for a specific age group and a specific chair. For greater visibility and simplification of the different types and dimensions of chairs, a system can be introduced in which each different chair has a specific color. In this way, children would more easily recognize "their color" and could always use the appropriate size of the chair throughout the year. Ultimately, this problem is multidisciplinary and should be addressed by multidisciplinary teams of experts.

Author contribution statement

Boris Iliev: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Danijela Domljan: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Zoran Vlaović: Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data associated with this study has been deposited at Repozitory of the University of Zagreb Faculty of Forestry and Wood Technology, urn:nbn:hr:108:425470

Declaration of interest's statement

The authors declare no competing interests.

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