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Discrepancy between pupils' body and classroom furniture in elementary schools: A case study in the Republic of Kosovo

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Abstract.
BACKGROUND: Primary school children spend quite a lot of time sitting in classrooms. For this reason, it is necessary to make a scientific analysis of children's body dimensions and compare them with the furniture dimensions where they sit.
OBJECTIVES: The main aim of this paper is to present anthropometric data for pupils in primary schools in the Republic of Kosovo and give recommendations for school furniture design.
METHODS: Measurements were made in the public schools of four different regions in the Republic of Kosovo. The study includes 720 children from 12 different elementary schools with first and fifth graders (6–11 years old). Twelve body parts were measured: Stature, sitting height, shoulder height, lower leg length, hip breadth, elbow height, buttock-popliteal length, thigh clearance, eye height, shoulder breadth, and knee height. The descriptive data are calculated in terms of average, standard deviation, and 5th, 50th and 95th percentile.
RESULTS: We recommend that the competent authorities in the Republic of Kosovo consider improving the infrastructure of primary schools in terms of furniture size according to the findings presented in this study.
CONCLUSIONS: The information presented in this paper on pupils' anthropometry and the proposed dimensions for school furniture can be used by various bodies in Kosovo including, but not limited to: Ministry of Education Science and Technology, Ministry of Trade and Industry of Kosovo and furniture manufacturing industries as basic information for suitable furniture design for primary school children, as well as school principals to help in furniture selection.

Keywords: Furniture, children, discrepancy, school, anthropometric, measurements

1. Introduction

Growth is defined as physical body change [1] that usually takes place from birth to the age of 18–23. During this period, the human body undergoes significant changes. For children in the Republic of Kosovo, the age of six represents a great change in their lives. At this age, they start school and spend quite a lot of time sitting on school benches. Being seated on a bench for a long time usually leads to children having a drooping posture, which consequently causes extreme strain on the muscles, ligaments and in particular the neck and spine disc [2–4].

Static posture and sitting in a bent position for a long time, as elementary schoolchildren tend to do, creates a conflict between the natural tendency towards unrestricted physical movement and the need to maintain a seated position for a longer period of time [5].

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During school time, most activities such as reading, writing and others are performed in a sitting position. According to Castellucci et al. [6], children spend approximately 25% of the day at school, and around 80% of that time they spend sitting down on seats doing their school work.

In Kosovo, pupils from 1st to 5th grade spend about one-fifth (around 22%) of the day in school benches. Various authors have concluded that children during their time in school for every 90 minutes, they are seated for more than 60 minutes [7]. Considering the fact that, while at school, children have to stay seated for long stretches of time, the relevant authorities should take measures to ensure a comfortable stay for children.

Discrepancies between pupils' anthropometric dimensions sizes of school furniture have been reported in many countries such as the United States [8], India [9], Indonesia [10], Turkey [11], Greece [12, 13], Chile [14], United Arab Emirates [15], Saudi Arabia [16], Korea [17] and elsewhere around the world. Discrepancies between the dimensions of school furniture and the pupils' anthropometric dimensions have been reported as a serious problem for the abovementioned countries.

The discrepancy between pupils' anthropometric dimensions and school furniture causes serious problems for pupils. In this regard, researchers have given their opinions. According to Murphy et al. [18], in British schools, there is a correlation between furniture inadequacy and pain in different parts of the body (including neck, back, waist, etc.). Some countries decide to use certain sets of standards to define the type of furniture dimensions that should be used according to pupils anthropometric characteristics [19].

These standards exist in Kosovo as well, and they clearly define the type and dimensions of furniture in accordance with the characteristics of pupils (Kosovo Standardization Agency 2019, SK EN 1729-1:2015/AC:2019). Due to the complexity of design problems, innovative solutions for school furniture should be found by establishing multidisciplinary teams composed of orthopedic doctors, rehabilitation experts, teachers, psychologists, constructors, technologists, environmentalists, economists and, of course, designers [20, 21]. Recent studies have shown an increase in musculoskeletal problems in primary school children [22].

If, through improper anthropometric design, the chair did not allow to the majority of users to, in fact, have foot or back contact with other surfaces, body instability would be increased, and additional muscular force would have to be introduced in order to maintain proper equilibrium. The greater the degree of muscular force or control required, the greater the fatigue discomfort [23]. According to chair height researchers [23], "by and large, however, a tall person would be far more comfortable using a chair with a low seat height than a short person using a chair with a seat height that is too high". School furniture that provides a comfortable sitting position for elementary school pupils and better concentration during classes should be considered [24]. Other researchers have also given similar views on the impact of furniture ergonomics on improving the quality of learning [25]. Anthropometric measurements are therefore an important consideration in designing ergonomically appropriate furniture for school children [26].

The availability of data on anthropometric measures, particularly for schoolchildren, is very limited in the Republic of Kosovo, and as a result, school furniture design is not based on anthropometric principles and according to standards. Thus, the study is focused on data collection to determine the potential discrepancy of dimensions between school furniture and the characteristics of primary school children in the Republic of Kosovo.

2. Methods

2.1. Participants

The participants in the study were children from four different cities in the territory of the Republic of Kosovo (Table 1). The sample size was calculated through Slovin's formula (1) [28]:

$$n = N/(1 + N[e]^2) \quad (1)$$

Where "n" is desired sample size; "N" is total population group, and "e" is the level of precision.

In our study, the level of precision is $\pm 4\%$. Therefore, N = 622. According to equation 1, the calculated sample size was 622. The number of children involved in this study were 720. The study involved

Table 1
The number of children by grades in primary schools in the Republic of Kosovo [27]

	The number of children according to grades					
	I	II	III	IV	V	Total
Total	25,138	24,678	25,778	25,103	24,582	125,279

Fig. 1. Regions in which samples were taken.

Table 2
The number of samples taken in the study by region, age, and gender

Region	Frequency	Percent
Prishtina	180	25%
Ferizaj	180	25%
Gjilan	180	25%
Peja	180	25%
Total	720	100%
	Frequency	
Gender		
F	359	49,9%
M	361	50,1%
Total	720	100%
	Classes	
Grades	Frequency	Percent
1	144	20%
2	144	20%
3	144	20%
4	144	20%
5	144	20%
Total	720	100%

both males and females from public schools in four different regions in the Republic of Kosovo (Fig. 1).

As can be seen in Table 2, the percentage of females is 49,9% and that of males is 50,1%. The sample size for each grade is 144, and for each region 180.

2.2. *Procedures*

Permission to conduct the research was obtained from the school authorities. Schools that declined to participate were replaced by other schools in the same study area. The schools were all selected randomly (three schools in each region). Within each of the 12 selected schools (out of 1058 primary schools of Republic of Kosovo) (Ministry of Education, Science, Technology and Innovation, Statistical Notes 2020/21; https://masht.rks-gov.net/statistikat), 60 children were selected randomly (approximately half of them were male and half female) including 12 children for each grade, 1 to 5 (6–11years).

The division of classes from 1st to 5th grade was done since these groups of pupils had the same shift (i.e., the afternoon shift from 13:00–17:00). It is worth noting that in the morning shift (08:00–13:00) the same classrooms are used by 6th and 9th graders.

2.3. *Measuring the dimensions of children and school furniture*

All anthropometric measurements were collected while pupils were sitting in an erect position on a bench, with knees bent at 90°. Like many other

a. *b.* *c.* *d.*

Fig. 2. a. and b. Classroom's furniture, c. and d. Process of measurements.

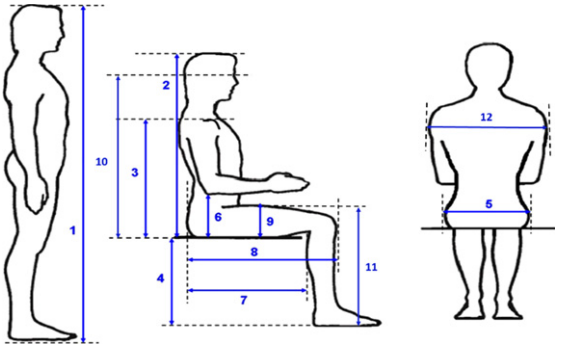

Fig. 3. Anthropometric measurements: 1. Body stature, 2. Sitting height erected, 3. Shoulder height, 4. Popliteal height, 5. Hip breadth, 6. Elbow height, 7. Buttock-popliteal length, 8. Buttock-knee length, 9. Thigh clearance, 10 Eye height, 11. Knee height, 12. Shoulder breadth.

Table 3
Body part measurements [32, 33]

No.	Measured body parts
1.	Stature (body height)
2.	Sitting height (erected)
3.	Shoulder height, sitting
4.	Popliteal height
5.	Hip breadth, sitting
6.	Elbow height, sitting
7.	Buttock-popliteal length
8.	Buttock-knee length
9.	Thigh clearance
10.	Eye height, sitting
11.	Knee height
12.	Shoulder breadth

researchers, the body dimensions in this study were also measured using traditional tools [29]. Anthropometric measurements of pupils were made in April-June 2020. During the measurements, the pupils were not wearing shoes, and 2,5 cm are added for the shoes [30, 31]. In accordance with international norms of anthropometric standards (ISO 7250-1, 2017), twelve parts of children's bodies were measured (Fig. 3, Table 3).

2.4. Measuring the dimensions of furniture

The classroom furniture, which were taken in the study, consist of the same designs but with few changes in dimensions, as can be seen in Table 4.

2.5. Data validation

The internal consistency between items in a scale was determined through Cronbach's alpha. Cronbach's alpha determined the internal consistency of the collected and analyzed data. Since the alpha value is high, all collected data and analyzed data were high in consistency [29]. As can be seen in Table 5, internal consistency is excellent [7].

2.6. Mismatch criteria

To determine the anthropometric criteria of furniture, in addition to the data collected, the calculation to determine the degree of their compatibility or discrepancy must also be done. In calculating the data, the theoretical and practical principles of ergonomics have been considered. Using the combination of formulas, the minimum and maximum limits are defined so that any dimension that falls within these values is considered appropriate [12].

The collected data were analyzed by means of descriptive statistics. Values for minimum (min), maximum (max), standard deviation (SD), percentages 5th, 50th, 95th and mean are taken into consideration.

Table 5
Calculation of Cronbach's alpha includes 12 items

Reliability statistics		
Cronbach's alpha	Cronbach's alpha based on standardized items	No. of items
0,946	0,960	12

Table 4
Dimensions of the classroom furniture measured in four regions taken in the study

No.	Measured parts	Dimensions of chairs (cm)			
	Chairs	Ferizaj	Prishtina	Peja	Gjilan
1	Chair height	85,5	79,5	85,5	80,5
2	Seat height	44,0	43,0	45,0	43,5
3	Seat depth	40,0	40,0	38,0	40
4	Seat width	40,0	40,0	38,0	40
5	Backrest height	41,5	36,5	40,5	38
No.	Tables	Dimensions of tables			
1	Height (for all regions)	76			

2.6.1. Popliteal height (PH) - seat height criteria

Previous studies show that the seat height needs to be adjusted according to the popliteal height [34, 35], thus allowing the knee to be flexed so that the lower leg forms a maximum of 30° angle relative to the vertical axis. As shown in Equation (2), the seat height needs to be lower than popliteal height so that the lower leg forms a 5–30° angle relative to the vertical and the shin-thigh angle is between 95° and 120° [26]. While researching the literature other criteria for determining seat height may be encountered [13, 21].

Various researchers have given different theories regarding the height of shoes [10, 36]. In this study, according to measures, a 2.5 cm for shoe correction was added to the popliteal height. Therefore, the match criterion was defined according to Equation (2) [6, 37]:

$$(PH + 2.5)COS30^{\circ} \leq SH \leq (PH + 2.5)COS5^{\circ} \quad (2)$$

Where: SH - is seat height and PH - is popliteal height.

To ensure clearance, 5th percentile data should be used to determine the chair height [23].

2.6.2. Hip breadth (HB) - seat width criteria

Seat width discrepancy occurs when hip breadth is greater than the width of the seat [38]. The seat width should be large enough to accommodate users with the largest hip breadth [31, 33, 35] and therefore is designed for the 95th percentile of the hip width distribution or the largest hip width [37, 39–41]. Gouvali and Boudolos [12] recommend that the seat width should be at least 10% (to accommodate hip breadth) and at the most 30% (for space economy) larger than the hip breadth, which is shown in Equation (3):

$$110\%HB \leq SW \leq 130\%HB \quad (3)$$

Where: SW - is seat width and HB - is hip breadth.

2.6.3. Buttock-popliteal length (BPL) - seat depth criteria

According to Panero [23], 5th percentile of data should be used. These will accommodate the greatest number of users: those with shorter buttock-popliteal lengths as well as those with greater lengths. If 95th percentile of data are used, the design will accommodate the users with the larger measurements only, but not those with smaller measurements [23].

The discrepancy is determined when the seat depth is >95% or <80% of the buttock-popliteal length [8]. Gouvali and Boudolos [12] have other opinions regarding seat depth criteria. Thus, the match criterion was determined by Equation (4):

$$80\%BPL \leq SD \leq 95\%BPL \quad (4)$$

Where: SD is seat depth and BPL is buttock popliteal length.

2.6.4. Shoulder height (SH) - backrest height criteria

It is considered appropriate when it is below scapula [39, 41, 42] to facilitate mobility of the trunk and arms [43]. As a result, the equation recommends keeping the backrest lower than the scapula, or at most on the upper edge of the scapula (60–80% of shoulder height). Thus, the match criterion was determined by Equation 5 [12]:

$$0.6SH \leq BH \leq 0.8SH \quad (5)$$

Where: BH - is backrest height, and SH - is the shoulder height.

2.6.5. Desk height (DH) - desk height criteria

The minimum and maximum value of the desk height was determined according to Gliem et al. [8]. To determine acceptable desk height is used the Equation (6).

$$hE = hEv + U([1 - \cos f] + \cos f[1 - \cos b)] \quad (6)$$

Where: hE - acceptable elbow rest height with shoulder flexion and abduction [8], hEv - the vertical elbow height, U = hS - hEv - is the upper arm length, θ - is shoulder flexion, β - is shoulder abduction, hS - the shoulder height.

According to Chaffin et al. [44], the minimum and maximum acceptable angle of the shoulder during writing is 0–25 degree for shoulder flection and 0–20 degrees for shoulder abduction. For flexion angles, the corresponding cosines are 1 (0 degrees) and 0.9063 (25 degrees) and for abduction angles, the corresponding cosines are 1 (0 degrees) and 0.9397 (20 degrees). Given that the cosines are monotone functions of the angles, a student's minimum desk height is determined by the vertical elbow height alone, Equation 7.

$$hE = hEv + U[(1 - 1) + 1(1 - 1)] = hEv \quad (7)$$

The maximum desk height is determined by Parcells et al. [8]:

$$hE = hEv + U[(1 - \cos f) + \cos f(1 - \cos b)]$$
$$= hEv + U[(1 - 0.9063) + 0.9063(1 - 0.9397)]$$
$$= hEv + U(0.1483) = hEv + 0.1483hS$$
$$-0.1483hEv = 0.8517hEv + 0.1483Hs,$$
$$since\ U = hS - hEv.$$

The maximum and minimum height of the table is calculated from the surface of the floor.

3. Results and discussion

The furniture in all schools that were the focus of this study have approximately the same design and dimensions. Statistical data for grades I–V, including minimum values, maximum, standard deviation, and the percentages of anthropometric data (5th, 50th, 95th) for different parts of the children's bodies are shown in Tables 6 and 7.

3.1. Seat height

As can be seen in Fig. 4, there is an absolute discrepancy between the anthropometric dimensions of the first graders and the height of the seat. In the second grade, it is seen that only 0,7 % of children have anthropometric dimensions which correspond to the dimensions of the seat height. 99,3% of them do not match the seat height. In the third grade, it is seen that 2,8% of children have anthropometric dimensions which fit the dimensions of the seat height, while 97,2% of children do not fit these dimensions. In the fourth grade, 9,0% of children fit to the dimensions of the chair height, while 91,0% of these children have smaller popliteal buttock dimensions compared to seat height. The seat height dimensions are slightly more proportional to the measurements of fifth graders, where 28,5% of them have dimensions that fit the height of the seat, while 71,5% of them have inconsistencies of anthropometric dimensions. In general, only 8,2% of children in grades I–V have dimensions that fit the dimensions of the seat height.

Referring to data from the scientific literature [23], the height of the seat should be such as to accommodate 5% of the population considered. Recommendation for chair height of children attending schools in the Republic of Kosovo are as follows: for first grades 25,1–28,9 (2,8) cm, for second grades 26,6–30,6 (2,9) cm, for third grades 29,6–34,0 (2,4) cm, for fourth grades 29,4–33,9 (3,0) cm, for fifth grades 33,1–38,0 (2,3) cm.

3.2. Seat depth

As can be seen in Table 4, the depth of the chair ranges between 38,0–40,0 mm. In Fig. 5, it is shown that only 2,8% of first graders have a body size that's appropriate to the dimensions measured in the field. The remaining 97,2% of children do not fit into these dimensions because the depth of the seat is too large. 4,9% of second graders have appropriate body dimensions, while 94,4% of the dimensions do not fit the depth of the chair due to it being too large. 12,7% of third grade children have appropriate dimensions, while 87,3% of them mismatch the dimensions in terms of large chair depth. 16,2% of fourth grade children fit the dimensions, while 83,8% of children learn in seats that have high depth. 38,7% of fifth grade pupils have anthropometric dimensions, which fit the depth of the seat, 61,3% of them have smaller dimensions compared to the depth of the seat.

Referring to scientific data [23], the depth of the seat should be such as to accommodate 5% of the population considered. Recommendations for the depth of the seat for children attending schools in the Republic of Kosovo: for the first grade 23,4–27,8 (2,2) cm, for the second grade 25,6–30,4 (2,4) cm, for the third grade 27,2–32,3 (2,1) cm, for the fourth grade 28,8–34,2 (2,1) cm, for the fifth grade 29,4–35,0 (2,6) cm.

3.3. Seat width

In Fig. 6, 100% of first graders have a body size smaller than the width of the seat, only 1,4% of second graders have dimensions larger than seat width. Amongst third graders it can be noted that 0,7% of pupils have body dimensions which fit the width of the seat, while 97,9% of them have smaller dimensions compared to the width of the seat, 1,4% of pupils have larger body dimensions than the seat width. 2,1% of fourth graders have body dimensions that fit the width of the seat, 95,1% of them have smaller body dimensions than the width of the seat and 2,8% of them have dimensions higher than the width of the seat. 2,8% of fifth graders have body dimensions that fit the width of the seat, 91,0% have a body width less than the width of the seat and 6,3% have body dimensions larger than the width of the seat.

Table 6
Anthropometric measures of primary school pupils (cm)

	Grade level																							
	I				II				III				IV				V				All grades			
	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD
												Stature												
Girls	110,6	144,8	122,7	6,6	110,0	148,0	128,6	6,4	124,0	151,0	134,9	6,3	126,4	154,2	139,8	6,5	130,5	165,9	147,6	7,8	110,0	165,9	134,8	10,9
Boys	108,2	168,0	124,1	9,0	110,2	146,6	129,5	6,7	123,6	149,8	135,5	6,0	121,0	162,0	138,5	7,1	131,1	157,2	145,0	6,8	108,2	168,0	134,4	10,2
												Sitting_height												
Girls	54,1	74,5	63,1	3,5	59,0	75,5	66,0	3,6	61,0	77,7	69,1	3,6	62,0	78,0	70,7	3,4	66,5	83,5	75,0	4,4	54,1	83,5	68,8	5,5
Boys	52,5	71,0	63,9	3,8	54,0	80,0	66,2	4,4	53,2	76,8	69,3	3,9	61,4	78,0	70,1	4,0	61,7	79,8	73,1	4,1	52,5	80,0	68,5	5,1
												Eye_height												
Girls	40,7	63,2	51,3	3,9	46,8	60,4	53,9	3,7	39,6	64,0	56,9	3,9	50,0	66,2	59,2	3,6	42,7	76,6	63,2	5,2	39,6	76,6	56,9	5,8
Boys	39,0	59,0	51,6	4,1	42,2	63,0	54,0	4,2	51,5	67,1	57,4	3,2	49,3	67,0	58,0	3,5	40,3	69,3	61,4	4,5	39,0	69,3	56,5	5,2
												Shoulder_height												
Girls	33,7	48,4	40,3	3,1	36,0	50,5	41,9	3,2	37,0	55,3	44,0	3,2	39,0	52,4	45,7	2,7	39,9	57,6	48,8	3,6	33,7	57,6	44,1	4,3
Boys	32,0	49,0	40,1	3,6	32,3	47,3	41,5	3,4	38,8	52,0	44,2	2,8	38,2	56,0	45,3	3,1	37,4	62,8	47,6	3,6	32,0	62,8	43,7	4,3
												Elbow_height												
Girls	10,1	22,3	15,1	2,7	11,3	21,0	15,2	2,0	10,5	22,2	16,7	2,4	12,6	23,0	18,1	2,2	14,5	25,0	19,0	2,6	10,1	25,0	16,8	2,9
Boys	10,2	21,1	15,0	2,1	10,0	20,0	15,2	2,3	11,5	23,2	16,6	2,4	13,4	24,0	17,6	2,2	11,8	24,5	17,7	2,7	10,0	24,5	16,4	2,6
												Thigh_clearance												
Girls	6,0	18,0	9,2	2,0	6,5	15,0	10,0	1,6	7,1	19,8	10,7	1,9	7,0	19,0	10,7	1,9	7,7	20,0	11,9	2,3	6,0	20,0	10,5	2,1
Boys	5,5	19,0	9,5	2,3	6,0	15,0	10,1	1,7	7,0	15,8	10,6	2,0	7,6	19,3	10,8	2,1	7,2	16,8	11,3	2,1	5,1	19,3	10,5	2,1
												Popliteal_height												
Girls	26,5	40,1	33,7	3,0	29,0	43,2	35,6	3,1	33,0	44,4	38,3	2,6	33,0	48,5	40,1	3,3	37,0	49,0	42,6	2,4	26,5	49,0	38,0	4,3
Boys	28,5	41,1	34,1	3,1	29,0	44,8	36,3	3,1	34,0	45,2	38,5	2,5	31,5	45,2	39,4	3,1	36,0	48,3	42,0	2,6	28,5	48,3	38,0	3,9
												Knee_height												
Girls	31,0	45,3	39,3	2,7	35,5	50,4	41,5	3,0	38,3	53,0	44,4	2,8	37,5	53,2	45,5	3,5	43,6	56,7	49,9	3,0	31,0	56,7	44,1	4,7
Boys	34,5	47,0	40,2	3,2	34,0	49,5	42,0	3,0	39,6	52,4	44,6	3,1	37,0	52,0	45,1	3,5	41,0	55,0	48,9	3,3	34,0	55,0	44,1	4,4
												Buttock_popl_length												
Girls	26,4	41,2	33,6	2,4	30,5	40,5	35,4	2,5	31,0	44,5	37,6	2,3	30,7	46,0	39,6	2,5	36,0	48,2	42,1	2,8	26,4	51,0	37,7	4,0
Boys	28,5	41,0	33,7	2,6	31,0	42,3	35,3	2,4	31,5	45,0	37,5	2,5	31,0	48,2	38,9	2,2	34,8	48,0	40,9	3,1	28,5	48,2	37,2	3,6
												Buttock_knee_length												
Girls	32,6	47,1	40,0	2,6	36,3	49,8	42,1	2,8	38,7	53,0	44,4	2,9	40,7	54,3	46,7	2,7	42,5	60,0	49,9	3,8	32,6	60,0	44,6	4,6
Boys	34,0	48,0	39,8	2,8	34,8	52,0	41,9	2,9	38,0	55,0	44,3	2,8	38,0	60,0	45,8	2,8	39,0	57,2	48,7	3,8	34,0	60,0	44,1	4,3
												Shoulder_breadth												
Girls	24,0	34,5	29,4	2,5	26,6	39,7	31,3	2,7	25,0	39,1	32,7	2,7	28,8	42,4	34,0	2,6	28,4	44,0	35,9	3,3	24,0	44,0	32,7	3,6
Boys	26,0	40,0	30,6	3,2	26,0	43,0	31,7	2,7	28,0	39,7	33,5	2,5	28,0	42,5	34,7	3,0	29,0	45,0	36,1	3,4	26,0	45,0	33,3	3,6
												Hip_breadth												
Girls	17,1	34,3	23,6	2,9	22,0	33,0	25,7	2,2	21,5	40,2	27,8	3,5	23,0	38,4	28,1	3,2	23,0	40,0	30,1	3,5	17,1	40,2	27,1	3,8
Boys	17,0	33,5	24,3	3,1	20,6	40,0	26,2	3,3	22,5	35,0	27,5	2,6	20,5	38,4	28,7	3,2	22,0	38,8	29,5	3,6	17,0	40,0	27,2	3,7

Table 7
Calculation of anthropometric data (5th; 50th; 95th centile)

	Grade level																	
	I			II			III			IV			V			All grades		
	5th %tile	50th %tile	95th %tile	5th %tile	50th %tile	95th %tile	5th %tile	50th %tile	95th %tile	5th %tile	50th %tile	95th %tile	5th %tile	50th %tile	95th %tile	5th %tile	50th %tile	95th %tile
								Stature										
Girls	113,0	122,4	133,6	120,4	128,0	138,8	126,3	135,4	148,1	129,4	140,0	150,0	134,7	147,5	160,6	117,0	134,5	154,2
Boys	111,7	123,0	136,3	116,9	130,1	141,0	125,8	135,0	145,7	126,7	139,2	149,4	133,9	145,6	155,5	118,0	134,2	151,8
								Sitting_height										
Girls	57,8	63,0	68,6	60,0	66,0	71,9	63,2	69,5	75,8	65,0	70,6	76,3	68,1	75,1	82,7	60,0	69,0	78,8
Boys	57,1	64,3	69,0	58,2	66,0	73,3	63,4	70,0	74,7	62,3	70,6	76,7	63,9	73,6	78,8	60,0	68,6	76,8
								Eye_height										
Girls	44,6	51,3	56,9	47,3	53,3	60,0	51,0	57,1	63,2	53,4	59,2	65,1	55,2	63,0	72,0	47,5	56,7	67,0
Boys	44,7	52,1	58,1	46,9	54,0	60,5	52,5	57,2	63,3	51,8	58,0	63,6	54,7	60,8	68,1	47,7	56,7	65,8
								Shoulder_height										
Girls	35,6	39,8	47,2	37,1	42,0	47,1	38,5	44,0	48,4	41,0	45,5	50,5	43,1	48,7	56,6	37,5	44,0	51,2
Boys	34,3	40,0	47,3	34,4	41,9	46,3	39,5	44,0	49,6	40,5	45,0	49,5	42,0	48,0	53,4	36,2	44,0	50,0
								Elbow_height										
Girls	11,1	14,9	21,0	12,2	14,7	19,0	12,5	16,8	21,0	14,7	18,0	22,0	15,1	19,0	24,0	12,5	16,6	22,0
Boys	11,1	15,0	18,6	10,7	15,5	18,7	12,4	16,5	20,3	13,9	17,5	21,2	12,9	17,7	22,1	12,3	16,2	20,6
								Thigh_clearance										
Girls	6,3	9,1	12,2	7,4	10,0	12,4	7,8	10,5	13,2	7,8	10,7	13,5	8,5	11,5	16,0	7,3	10,4	14,0
Boys	6,1	9,3	14,0	6,9	10,1	12,6	7,3	10,4	14,6	8,1	10,6	15,2	8,1	11,0	15,1	7,0	10,3	14,3
								Popliteal_height										
Girls	27,9	33,5	38,8	30,4	35,5	41,0	34,4	38,0	43,3	34,0	40,0	46,4	38,3	42,8	46,0	31,4	38,0	45,0
Boys	29,4	33,9	39,7	30,7	36,0	41,6	34,0	38,3	43,0	34,0	40,0	44,0	37,7	42,1	46,2	31,0	38,0	44,5
								Knee_height										
Girls	35,1	39,0	44,1	37,0	41,0	47,2	40,0	44,0	49,3	39,0	45,7	51,3	44,0	50,5	54,7	37,3	43,9	52,0
Boys	35,1	40,1	46,7	35,4	42,0	46,7	40,0	44,0	50,3	38,6	45,8	50,2	43,7	49,3	54,2	37,0	44,0	52,0
								Buttock_popl_length										
Girls	29,2	33,5	37,2	31,6	35,5	40,0	33,9	37,3	41,9	36,0	39,4	44,4	37,0	42,0	46,4	31,3	37,5	45,0
Boys	29,7	33,4	40,0	31,9	35,0	40,2	33,8	37,6	42,3	35,5	39,0	42,2	35,9	41,0	46,9	31,5	37,0	43,2
								Buttock_knee_length										
Girls	36,2	40,0	44,7	37,6	41,7	47,5	39,9	44,3	50,0	42,1	47,0	52,2	43,6	49,4	56,1	38,0	44,3	53,5
Boys	36,0	39,8	45,1	37,0	41,7	47,6	40,5	43,9	50,0	42,0	45,8	49,5	42,9	48,6	55,3	37,0	43,8	52,0
								Shoulder_breadth										
Girls	25,0	29,0	34,1	27,6	30,5	37,2	28,6	33,0	37,7	30,0	34,0	39,4	30,7	36,0	41,4	27,0	32,5	39,0
Boys	26,0	29,9	37,2	27,0	31,5	35,3	29,6	33,0	38,0	29,7	34,8	40,0	31,3	35,8	42,0	28,0	33,0	40,0
								Hip_breadth										
Girls	19,3	23,5	28,3	22,8	25,1	30,9	22,1	27,4	33,2	24,0	28,1	35,3	25,5	29,1	37,8	21,7	26,5	34,0
Boys	20,4	24,0	31,4	22,0	25,5	31,8	23,4	27,0	33,0	24,1	29,0	34,4	24,3	29,1	38,0	22,0	27,0	34,0

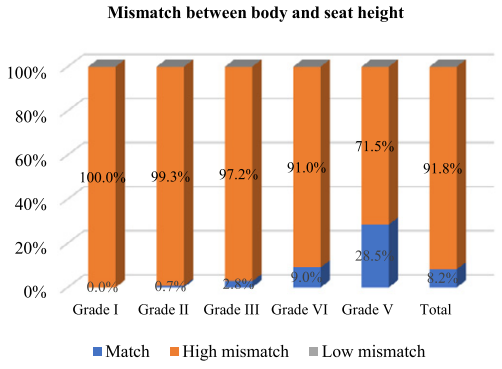

Fig. 4. Mismatch percentage for seat height according to grades I–V.

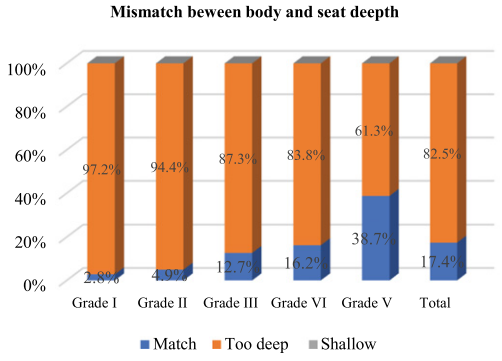

Fig. 5. Mismatch percentage for seat depth according to grades I–V.

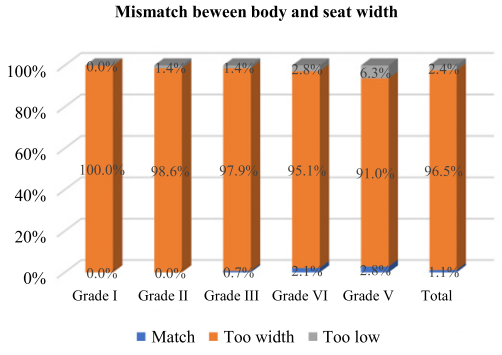

Fig. 6. Mismatch percentage for seat width according to grades I–V.

Ansari et al. [45] recommend that the width of the seat should be such as to accommodate 95% of the population considered. Recommendations for the width of the seat for children attending schools in the Republic of Kosovo: for the first grade 32,9–38,9 (3,6) cm, for the second grade 34,0–40,2 (3,4) cm, for the third grade 36,3–42,9 (3,7) cm, for the fourth

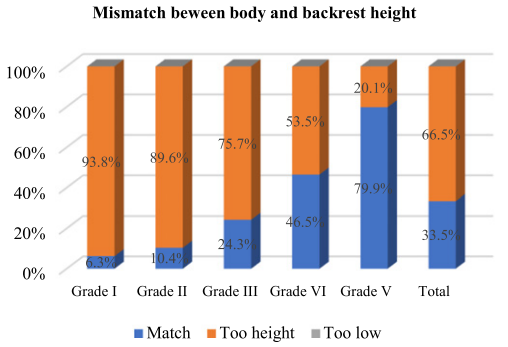

Fig. 7. Mismatch percentage for backrest height according to grades I–V.

grade 38,3–45,2 (3,8) cm and for the fifth grade 41,5–49,1 (4,3) cm.

3.4. Backrest height

In general, there is agreement between researchers that the primary purpose of the backseat of chair is to provide lumbar region support [46, 47]. Adequate lumbar support is the most crucial element of a backrest. Inadequate lumbar support places excess pressure on the spine. Figure 7 shows that 6,3% of children fit the backrest height, while 93,8% of first graders do not fit the backrest height because it is too high. Amongst second-grade pupils, it is noted that 10,4% of children fit the dimensions of the backrest height, while 89,6% have smaller dimensions compared to backrest height. The third graders fit 24,3% of dimensions, while the inconsistency to the backrest height is 75,7%. The fourth graders fit 46,5% of dimensions, while the inconsistency to the backrest height is 53,5%. 79,9% of fifth graders have dimensions that fit the height of the backrest, while 20,1% of them have dimensions smaller than the backrest height.

Previous studies recommend that the height dimension of the backrest should be 5% [48] of population of the study. Recommendations for backrest height for first grade pupils are 20,9–27,8 (2,4) cm, for the second graders 22,1–29,4 (2,3) cm, for third graders 23,5–31,3 (2,1) cm, for the fourth graders 24,6–32,8 (2,0) cm, for the fifth graders 25,6–34,1 (2,6) cm.

3.5. Desk height (minimum and maximum)

As one of the most important pieces of furniture, the desk height should be appropriate for children to feel comfortable while working on it. Field mea-

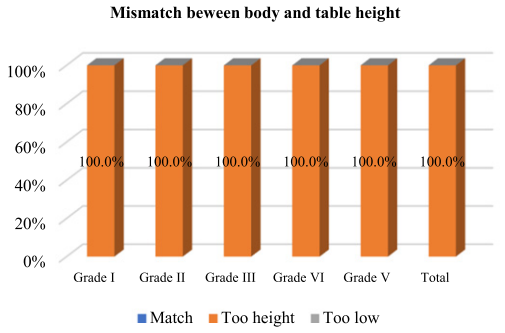

Fig. 8. Mismatch percentage for table height according to grades I–V.

surements show that the desk height is 76,0 cm. The definition of the 95th percent of the desk height is taken according to the recommendations of Rosyidi et al. [36]. Figure 8 shows that the height of the desk exceeds all the heights of the measurements, consequently there is no pupil who has body dimensions that fit the current dimensions of the school desks (Table 8, Fig. 9).

Recommendations for student desk heights are: for the first grades 56,5–66,9 (3,2) cm, for the second grades 58,5–67,7 (3,0) cm, for the third grades 61,2–68,2 (2,9) cm, for the fourth grades 64,0–69,4 (3,0) cm, for the fifth grades 67,4–71,2 (3,3) cm.

4. Conclusions

The main purpose of this study is to analyze the discrepancy between anthropometric dimensions of children and dimensions of school furniture in the Republic of Kosovo.

The data in this research show results obtained from 720 children of grades 1–5 (ages 6–11 years). Although the study included 144 children for each grade, the good sample distribution (divided into the 4 largest regions of the country) allows us to consider that the paper represents an inclusiveness and that it can be a good indicator and can be regarded as a general study for all countries.

The results speak of a noticeable discrepancy between the anthropometric dimensions of the children and the dimensions of the furniture (chair and table) in which they sit during their classes. High mismatching was found in the height and depth of the chair and in the height of the work desk, which are considered critical dimensions when sitting on them. Also, significant discrepancies were found in the width of the chair and at the height of the chair backrest.

Table 8
Comparisons of average stature between children of the same ages in Chile, Belgium and Kosovo (F-Female; M-Male)

Age	F10		M10		Mix 10		F9		M9		Mix 9		F8		M8		Mix 8		F7		M7		Mix7		F6		M6		Mix6	
Mean/SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Chile [49]	1427	7	1430	7	1429	7	1379	6	1361	7	1370	11	1323	6	1317	5	1320	6	1244	5	1263	4	1254	11	1193	5	1217	5	1205	13
The Netherlands [50]	1471	66	1460	68	1466	67	1392	64	1418	55	1405	61	1341	54	1340	50	1341	52	1286	57	1287	53	1287	55	1227	49	1225	47	1226	48
Kosovo	1458	74	1435	72	1447	72	1372	70	1375	70	1374	65	1272	66	1332	68	1331	59	1269	65	1272	65	1271	69	1208	63	1240	64	1219	73

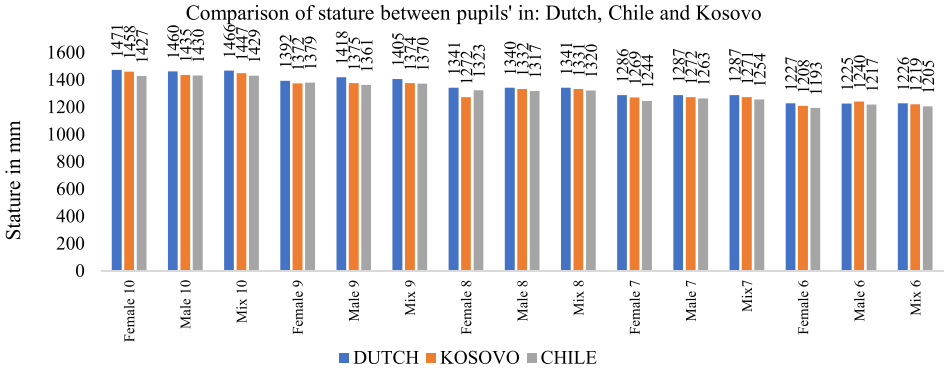

Fig. 9. Comparison of stature according to data for countries: Kosovo, The Netherlands, Chile.

The use of poorly designed school furniture increases the possibility of pupils' health problems. Moreover, this phenomenon affects pupils of young ages more.

Based on anthropometric measurements made of pupils, new dimensions have been recommended that primary schools in Kosovo should use. Based on data from other researchers who point out the importance of matching school furniture dimensions to children's body size and given the other design requirements and financial limitations for 1058 (Ministry of Education, Science, Technology and Innovation, Statistical Notes 2020/21; https://masht.rks-gov.net/statistikat) primary schools of Kosovo, we consider that where it is possible, these data should be considered to improve school facilities continuously.

5. Future research

The results presented in this paper are a good starting point to continue with further research in the future. The impact of furniture discrepancy in children's health problems in primary schools and the role of ergonomic furniture in improving the quality of learning in primary schools would be of particular interest to society in general. Also, it would be interesting to review the standard SK EN 1729-1:2015 / AC: 2019, which defines the dimensions of school furniture for primary school students in Kosovo and harmonize it with the research findings.

Conflict of interest

None to report.

Ethical approval

Ethical approval was obtained from the University of Applied Sciences in Ferizaj Ethics Commission (no. 1992/22/UASF, date 6/6/2022).

Informed consent

Not applicable.

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