Work 73 (2022) 229–245
DOI:10.3233/WOR-210487
IOS Press

Ergonomic evaluation of school furniture in Slovenia: From primary school to university

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Received 26 March 2021
Accepted 25 August 2021

Abstract.
BACKGROUND: Adequate school furniture is important to prevent musculoskeletal discomfort among students.
OBJECTIVE: The aim of the study was to assess the suitability of school furniture compared to body dimensions of students.
METHODS: A cross-sectional study included a total of 442 students from primary school, secondary school, and university. Nine body dimensions along with five furniture dimensions were measured and equations for mismatch criteria were applied.
RESULTS: In primary school, differences in body dimensions were more evident among students of different age, while in secondary school and university, differences between male and female students became more apparent. The mismatch for desk height ranged from 100.0% at primary school to 48.0% at university. Similarly, the seat height mismatch was the most evident in primary school (89.7%–94.6%), lower at university (52.0%) and the lowest in secondary school (18.0%). The seat depth mismatch was present among all groups, ranging from 23.1% to 40.4%, and was in general more pronounced in males. Seat to desk clearance mismatch was the most evident among secondary school students. In primary school, seat and desk height were generally too high for most of students.
CONCLUSIONS: Specific differences in body dimensions among groups of students of different age and gender were observed and a high student-furniture mismatch was identified in all educational institutions. Implementation of adjustable school furniture, covering at least two size marks, is needed to provide ergonomic and healthy learning conditions and to further enhance the comfort and well-being of students in the classroom.

Keywords: Classroom, furniture, school ergonomics, students

1. Introduction

Students spend a considerable amount of their waking time in school, where sitting is their predominant posture [1]. Literature shows that the onset of age-related increase in sedentary behaviour appears around six or seven years of age, which coincides with the start of schooling [2]. Sedentary behaviour might be associated with adverse health outcomes among children and adolescents, including unfavourable body composition and decreased fitness [3], lower insulin sensibility [4], decreased academic achievement, [3] and worse psychological well-being [5, 6]. In addition to sitting time, the quality of sitting also affects individual's health and self-esteem [7, 8]. Awkward posture and poor sitting habits acquired in childhood could be difficult to change later in adulthood. Therefore, it is necessary to encourage good postural habits of students, which could be done by providing students with ergonomic furniture that fits their body dimensions.

Growth pattern of school children differs [9] and body dimensions among individuals of the same age might deviate substantially. Despite that, school

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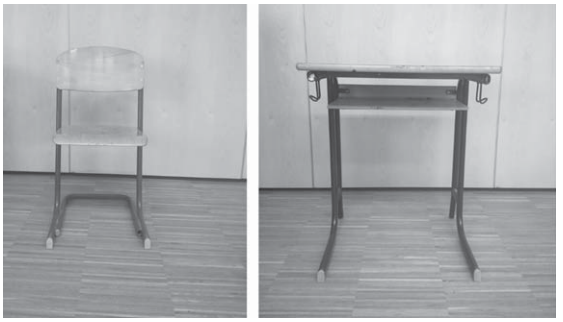

Fig. 1. Typical school furniture in Slovenia.

furniture comes in one size for all students in the classroom (Fig. 1). Consequently, incompatibility between students' body dimensions and furniture dimensions, defined as a student-furniture mismatch, may arise [10]. Inappropriate school furniture results in increased postural overload [11]. When the seat height is too low, the compression in the buttock region is increased, and when the seat height is too high, pressure on vascular and neural structures is increased [12]. Unsuitable school desk is associated with neck and shoulder pain while too low backrest might be one of the factors influencing lower back pain [13, 14]. Awkward body posture of students, resulting from inappropriate school furniture, might also affect students' attention and creativity [15]. On the other hand, if the students are using a more suitable school furniture, better academic performance can be achieved and musculoskeletal disorders can be reduced [16].

In order to quantify the rate of student-furniture mismatch, several equations have been proposed [17–22]. Studies from different countries have shown that the rate of mismatch in schools is high, ranging between 60% and 99% for seat height, between 55% and 99% for seat depth, and between 52% and 99% for desk height [19, 20, 23–27].

When assessing suitability of a school desk and chair, it is important to consider the activities that students most often perform in the classroom, such as reading, writing, and looking at the blackboard. Using the existing furniture (Fig. 1), with flat and non-adjustable desk and chair, students bent their trunk and neck forward during writing and reading [28]. Indeed, upright sitting with 90° in lower extremity joints may not be the optimal posture to sustain for long periods [29–31]. Mandal [30, 32] proposed an improvement in standard school furniture that included higher and sloping desktops and higher and forward inclined seat pans. Later research has shown that furniture proposed by Mandal was generally well accepted by students, and a more neutral posture was maintained when sitting in the classroom [33–35].

More recently, a student-centred approach has been adopted [36] and ways to decrease sitting time of students in the classroom have been investigated [37]. Layout of the classroom with furniture organised in rows is being replaced by flexible learning spaces that consist of a variety of furniture pieces and different layout options [38, 39]. Students' well-being in schools is influenced also by school environment. For example, good lighting, including daylighting and providing outdoor views from the classroom, can enhance safety, improve health, and learning outcomes of students [40].

Anthropometric data of Slovenian students are scarce, and knowledge about the ergonomic suitability of school furniture is lacking. Moreover, a comprehensive evaluation of school furniture suitability in all educational levels in Slovenia, including primary school, secondary school, and university, is not yet clear. To address the issue of student-furniture mismatch in different student populations (primary school, secondary school, and university students), it is important to determine which subgroups exhibit critical mismatch levels and which furniture dimensions need the most attention. The aim of this study was to obtain anthropometric data from Slovenian students, assess the relevant school furniture dimensional characteristics, calculate the rates of student-furniture mismatch in Slovenian primary and secondary schools, and university, and to calculate the recommended furniture dimensions, based on student's body dimensions. We hypothesised that: i) the student-furniture mismatch is present in all educational institutions, and ii) the most critical furniture dimensions are seat and desk height.

2. Methods

2.1. Participant recruitment

We included students from all three sections of education in Slovenia: primary, secondary, and tertiary. Primary school in Slovenia comprises of nine grades (from 1st to 9th grade), secondary education can last for four years (from 1st to 4th grade) or five years (3 years + optional 2 years), while tertiary education follows the Bologna system.

The study was conducted in the Slovenian Coastal-Karst region, which comprises 38 primary schools, ten secondary schools, and one university with seven faculties. In this study, three primary schools, three secondary schools, and one faculty with four study programmes were contacted to participate in the study. Finally, one primary school, one secondary school and two study programmes agreed to participate. The educational institutions included were all public and represented typical educational institutions in Slovenia. After school authorities approved the collaboration, students and their parents received a written invitation to participate in the study. The invitation included all relevant information for the study, the researcher's contact details, and informed consent to participate. For minor students from primary and secondary school, aged less than 18 years, informed consent also needed to be signed by their parents/guardians. Out of 550 students who volunteered to participate, 75 students were not present at school on the day when the measurements were taken, and 33 were excluded due to the incomplete informed consent. The final sample consisted of 442 students from primary school (155 students), secondary school (139 students), and university (148 students). Students who volunteered were generally healthy and had no physical or mental disabilities. Gender was self-reported by the students. The study was conducted in line with the latest revision of the Helsinki declaration and approved by the Slovenian National Medical Ethics Committee (number of approval 0120-347/2018/3). The study protocol was pre-registered with clinical trials under the registration number ID NCT03653767. The data analysed in the study were anonymous.

2.2. Anthropometric measurements

The anthropometric measurements were performed manually with GPM anthropometric measurement set (Gneupel Präzisions-Mechanik, Swizterland). All measurements were taken by a trained team of researchers who performed a pilot study to assess intra-rater (degree of agreement of single rater in one visit), inter-rater (degree of agreement among two raters in one visit) and inter-visit (degree of agreement of single rater in two separate visits) reliability to ensure high-quality measurements [41]. Intra class correlation (ICC) was interpreted as described by Koo and Mau [42]. Intra-rater reliability was good to excellent (ICC ranging from 0.85 to 0.99) for all measurements performed. Inter-visit reliability was moderate for scapular height (ICC 0.56) and thigh thickness (ICC 0.62) measurements, while reliability for other measures was good to excellent (ICC ranging from 0.75 to 0.99). Similarly, inter-rater reliability was moderate for subscapular height (ICC 0.52) and thigh thickness (ICC 0.61) measurements and good for other measures (ICC ranging from 0.76 to 0.88).

Except for body height and body weight, all anthropometric measurements were taken on the participant's right side, while wearing light clothes and no shoes. During the measurement, students sat upright on a chair with adjustable seat height and without a backrest, having ankles, knees, and hips bent at 90° and with feet completely on the floor. The described body posture was defined using a goniometer by identifying relevant bony anatomical landmarks. Body height was measured in an upright standing position. The anthropometric measures included body height, body mass, popliteal height, thigh thickness, elbow height, shoulder height, subscapular height, hip width, and buttock-popliteal length as these body dimensions are needed to calculate the suitability of school furniture. Detailed descriptions of body dimension measurements are presented in Table 1. During a single visit, each measurement was taken three times, and the average value was taken for further analyses.

2.3. School furniture measurements

Measurement of the classroom furniture was taken twice using a GPM tape and electronic inclinometer (Baseline Evaluation Instruments, Fabrication Enterprise Inc., USA), and average values were calculated for further analyses. The furniture measures included: seat height, seat depth, seat width, upper edge of backrest, desk height, and seat inclination as these furniture dimensions are used in further calculations.

2.4. Student-furniture mismatch calculation

To determine the discrepancy between the body dimensions of students and the dimensions of the school furniture, the mismatch was calculated using the equations proposed by Castellucci, Arezes and Molenbroek [17]:

- equation for seat height: *(popliteal height + shoe correction)*cos30°* $\leq$ ***seat height*** $\leq$ *(popliteal height + shoe correction)*cos5°*

Table 1
Description of measuring body dimensions in the study [17]

Body dimension	Measurement description
Stature	Vertical distance from the floor to the top of the head. Participant stands erect, looking straight ahead.
Shoulder height sitting	Vertical distance from subject's seated surface to the acromion.
Elbow height sitting	Vertical distance from the subject's seated surface to the olecranon (elbows in a 90° flexion).
Subscapular height	Vertical distance from the subject's seated surface to the inferior angle of the scapula.
Popliteal height	Vertical distance from the floor or footrest to the popliteal region.
Thigh thickness	Vertical distance from the subject's seated surface to the highest uncompressed point of the thigh.
Buttock-popliteal length	Horizontal distance from the posterior region of the buttock to the popliteal region.
Hip width	Horizontal distance between the widest points of the hip.

- equation for seat depth: *0.80*buttock popliteal length* $\leq$ ***seat depth*** $\leq$ *0.95*buttock popliteal length*
- equation for seat width: *hip width* $<$ ***seat width***
- equation for upper edge of backrest: *subscapular height* $\geq$ ***upper edge of backrest***
- equation for seat to desk clearance: *thigh thickness + 2* $<$ ***seat to desk clearance***
- equation for desk height: *(seat height – (sinX° *seat depth)) + elbow height sitting* $\leq$ ***desk height*** $\leq$ *(seat height – (sinX° *seat depth)) + elbow height sitting*0.8517 + shoulder height sitting*0.1483*

Because all the anthropometric measures were taken while participants wore no shoes, shoe correction for the seat calculations were considered (based on the measured sole of the students' shoes). A shoe correction of 0.5 centimetres was used for primary students (who wore slippers at school) and two centimetres for secondary school and university students (who most frequently wore sneakers at school).

2.5. Statistical analysis

The data were transcribed into Microsoft Excel (Microsoft 365, 2020) and analysed with SPSS Statistics for Windows, Version 26 (IBM Corp., Armonk, NY, USA) and R 3.6.1 (R Core Team (2019) using R Studio 1.2.1335) using "tidyverse" collection of packages. The data is presented as mean $\pm$ standard deviation, range (minimum and maximum), and 5th and 95th percentile. To explore differences in body dimensions among students, we have conducted a two-way ANOVA with grade and gender as factors. Independent *t*-test were applied to determine the differences between individual groups. For the effect size, partial eta squared (ηp^2) was included (small = 0.01, medium = 0.06, large = 0.14) [45]. Additional statistical analysis was performed to calculate if reallocating school chair or desk from one classroom to another would result in decreased mismatch among primary school students. The statistically significant differences were accepted at the significance level $\alpha < 0.05$.

3. Results

Out of 442 students included in the study, 76% were male and 24% were female, aged between 6 and 35 years. Student characteristics from primary school, secondary school, and university are presented in Table 2.

3.1. School furniture dimensions

Different types of classroom furniture were observed in primary school, secondary school, and university. In primary school, one type of school furniture was used for the 1st graders, one type for the 2nd and 3rd graders, one type for the 4th and 5th graders, and one type for the 6th to 9th graders. All students from secondary school used one type of furniture, and all students from university used one type of school furniture. The dimensions of the existing school furniture and the calculated range of acceptable furniture dimensions based on the students' anthropometry (5th, 50th, and 95th percentile) and mismatch equations are depicted in Table 3.

Table 2
Participant characteristics by institution

Institution			Body height (cm)	Body mass (kg)	BMI (kg/m^2)	Popliteal height (cm)	Thigh thickness (cm)	Elbow height sitting (cm)	Shoulder height sitting (cm)	Subscapular height sitting (cm)	Hip width (cm)	Buttock popliteal height (cm)
Primary school	Mean		146.2	40.3	18.4	39.1	11.2	18.5	46.8	35.6	30.5	41.8
(n = 155, 47,7%	Std. Dev.		14.2	12.4	3.2	4.5	1.8	3.0	5.5	4.4	4.9	5.0
males, age 6–15)	Minimum		117.5	19.8	12.8	28.6	7.5	5.1	35.3	25.3	19.9	31.5
	Maximum		184.0	82.7	30.4	49.3	21.3	28.5	60.2	47.6	44.3	54.0
	Percentiles	5	125.0	23.0	14.3	31.3	8.5	14.1	37.7	28.6	22.4	33.5
		95	170.0	64.4	24.1	45.9	14.6	23.4	55.9	43.4	39.6	49.9
Secondary school	Mean		177.5	74.1	23.5	45.7	15.4	23.8	59.7	46.0	36.9	51.4
(n = 139, 94,4%	Std. Dev.		7.7	15.7	4.6	2.4	2.0	2.6	3.1	3.0	3.5	2.7
males, age 14–20)	Minimum		151.0	47.7	16.9	36.3	10.0	16.6	51.0	37.8	29.4	43.4
	Maximum		192.0	139.5	45.0	51.3	21.0	29.5	65.4	53.0	49.9	57.9
	Percentiles	5	162.0	54.2	18.2	41.4	12.5	19.0	54.2	40.7	31.9	47.0
		95	189.0	105.0	32.9	50.0	18.9	27.9	64.4	50.9	43.2	55.5
University	Mean		170.3	66.2	22.7	43.2	14.5	24.5	58.6	46.2	40.1	49.2
(n = 148, 29,7%	Std. Dev.		9.1	11.4	2.7	2.9	1.8	2.4	2.9	2.8	2.6	3.1
males, age 18–35)	Minimum		153.0	45.8	16.4	37.6	11.1	18.2	52.2	40.4	33.7	41.1
	Maximum		194.0	95.5	35.5	51.0	19.9	31.9	65.9	56.4	51.9	59.5
	Percentiles	5	157.0	51.7	19.3	38.9	12.1	20.5	54.2	41.4	36.8	43.9
		95	186.0	89.8	27.9	48.0	17.9	28.8	63.8	50.3	44.4	54.5

3.2. Anthropometric measures

Descriptive statistics for the anthropometric measures of students grouped by grade level and gender are presented in Tables 4–6. The 5th and 95th percentiles for all values are presented in Fig. 2. In primary school, significant differences among students of different ages were observed whereas no significant differences among males and females were found (Table 7). Conversely, among university students, body dimensions differed mostly between male and female students and no significant differences were found among students of different grade levels. Total anthropometric dataset is available in the Appendix.

3.3. Student-furniture mismatch

The student-furniture mismatch is presented in Fig. 3 in percentages. In total, the mismatch for desk height decreased from 100.0% at primary school to 48.0% at university. Similarly, seat height mismatch was the most evident in primary school (up to 94.6%), lower at university (52.0%) and the lowest in secondary school (18.0%). However, it must be noted that in secondary school the seat height mismatch largely differed between male (17.2%) and female (40.0%) students. Due to the predominantly male students from secondary school, these results should be interpreted with caution. The seat depth mismatch was comparable among all groups, ranging from 23.1% to 40.4%. Seat to desk clearance was suitable for all students from primary school and university. In contrast, more than 90% of secondary school students did not have sufficient space for leg movement under the desk. The backrest height was too high for the majority of primary school students (except for 1st graders), and acceptable in secondary school and university.

The percentage of students whose body dimensions matched or mismatched the dimensions of school furniture by institution, grade, and gender are presented in Table 8. Gender differentiated results in the Table 8 should be viewed with caution due to the predominantly male students in secondary school and mainly female students at university. Below, detailed description of the mismatch results, based on grade level and gender, are described.

3.3.1. Primary school

Desk height was too high for all male and female students from 1st to 6th grade of primary school, whereas among 6th to 9th graders, desk height mismatch was more evident in males (93.3%) compared to females (73.7%). Of these, desk height was too high for all males and for 96.4% of females. Similarly, seat height was too high for the majority of primary school students, ranging from 73.7%–100.0%. In lower grades, seat depth mismatch was more pronounced in males (26.3%–40.0%) compared to

Table 3
School furniture dimensions and recommended school furniture dimensions based on students' body dimensio

@@	Primary school											
	1st grade				2nd-3rd grade				4th-5th grade			
	Existing furniture (cm)	5th %tile (cm)	Mean (cm)	95th %tile (cm)	Existing furniture (cm)	5th %tile (cm)	Mean (cm)	95th %tile (cm)	Existing furniture (cm)	5th %tile (cm)	Mean (cm)	95th %tile (cm)
Seat height (cm)	34	26.5–30.5	27.9–32.1	29.7–34.1	36.5	27.1–31.2	30.6–35.2	36.8–42.4	45.5	29.9–34.3	34.6–39.8	40.1–46.2
Seat depth (cm)	30	25.2–29.9	27.3–32.4	30.6–36.4	31	25.4–30.2	29.5–35.0	35.2–41.8	38	29.6–35.1	33.8–40.2	37.9–45.0
Seat width (cm)	31.5	>19.9	>24.5	>30.9	36.5	>21.7	>26.9	>34.0	38.5	>24.5	>30.9	>37.0
Upper edge of backrest (cm)	25	≤27.4	≤30.2	≤33.3	32.5	≤28.2	≤31.7	≤35.9	37	≤31.5	≤34.9	≤38.3
Desk height (cm)	58	50.1–53.3	52.4–55.7	54.2–57.8	64.5	51.1–54.8	54.9–58.7	58.5–63.0	75	63.8–67.6	66.5–70.6	70.4–74.6
Seat to desk clearance (cm)	15.5	>11.0	>12.7	>14.4	25.5	>10.0	>12.3	>15.5	27.0	>9.7	>12.9	>16.6
Seat inclination (cm)	–3.5				–3.5				–3.5			
	Primary school				Secondary school				University			
	6th–9th grade				1st–5th grade				1st–3rd grade			
	Existing furniture (cm)	5th %tile (cm)	Mean (cm)	95th %tile (cm)	Existing furniture (cm)	5th %tile (cm)	Mean (cm)	95th %tile (cm)	Existing furniture (cm)	5th %tile (cm)	Mean (cm)	95th %tile (cm)
Seat height (cm)	45.5	33.3–38.3	37.1–42.7	41.5–47.7	45	37.6–43.3	41.3–47.5	45.0–51.8	44.5	35.4–40.7	39.2–45.1	43.3–49.8
Seat depth (cm)	40	32.3–38.4	36.3–43.1	40.9–48.6	42	37.6–44.7	41.1–48.9	44.4–52.7	41	35.2–41.7	39.4–46.7	43.6–51.7
Seat width (cm)	41	>27.2	>33.2	>41.0	39	>31.9	>36.9	>43.2	47	>36.8	>40.1	>44.4
Upper edge of backrest (cm)	39	≤34.7	≤39.0	≤45.7	36	≤40.7	≤46.0	≤50.9	41.5	≤41.4	≤46.2	≤50.3
Desk height (cm)	75.5	63.0–67.5	67.8–72.4	72.5–77.6	76.5	66.2–71.4	71.0–76.3	75.1–80.5	76	67.5–72.5	71.5–76.6	75.8–81.0
Seat to desk clearance	19.5	>11.9	>14.0	>17.1	15	>14.5	>17.4	>20.9	29.0	>14.1	>16.5	>19.9
Seat inclination (cm)	–3.5				–3.0				–3.5			

Table 4
Anthropometric characteristics of primary school female and male students

Primary school		Body height (cm)		Body mass (kg)		BMI (kg/m^2)		Popliteal height (cm)		Thigh thickness (cm)		Elbow height sitting (cm)		Shoulder height sitting (cm)		Subscapular height sitting (cm)		Hip width (cm)		Buttock popliteal height (cm)	
		female	male	female	male	female	male	female	male	female	male	female	male	female	male	female	male	female	male	female	male
1st grade	Mean	121.1	127.0	22.0	29.5	15.0	18.2	31.2	32.2	9.8	11.5*	16.2	16.9	37.8	39.4	29.2	30.9	22.4	26.2	33.9	34.3
(females = 4,	Std. Dev.	5.3	2.9	2.4	7.1	0.6	3.8	1.4	1.4	0.9	1.1	1.6	1.1	2.3	2.2	2.8	1.3	1.4	4.4	1.6	2.7
males = 5,	Min.	117.5	123.4	20.2	19.8	14.4	13.0	30.1	30.4	9.0	9.6	14.2	15.5	36.0	36.4	27.4	29.5	20.6	19.9	31.6	31.5
age = 6–7)	Max.	129.0	131.5	25.5	38.2	15.6	22.1	33.1	33.8	11.1	12.4	18.0	18.4	41.1	42.5	33.3	32.5	24.0	30.9	35.3	38.3
	5 %tile																				
	95 %tile																				
2nd-3rd grade	Mean	130.9	134.9	28.6	33.5	16.6	18.2*	34.4	35.1	10.3	10.4	16.6	16.4	41.5	42.2	31.3	32.1	26.0	27.7	36.0	37.6
(females = 19,	Std. Dev.	4.7	10.1	6.6	8.0	3.0	2.5	1.8	3.2	1.6	1.4	2.2	2.3	2.9	3.7	2.2	2.4	3.9	3.7	2.3	3.4
males = 20,	Min.	122.5	123.9	21.6	23.2	13.5	14.8	31.5	30.1	7.5	8.1	11.5	12.7	35.3	37.5	27.6	28.2	21.7	21.4	31.8	31.5
age = 6–8)	Max.	139.0	165.5	44.0	53.2	22.8	23.3	36.9	42.5	13.5	13.0	19.5	20.2	45.9	51.8	35.1	36.9	33.3	36.0	40.8	45.6
	5 %tile	122.5	124.0	21.6	23.3	13.5	14.9	31.5	30.2	7.5	8.1	11.5	12.8	35.3	37.5	27.6	28.2	21.7	21.5	31.8	31.5
	95 %tile		164.8		53.2		23.3		42.4		13.0		20.2		51.7		36.9		35.9		45.5
4th 5th grade	Mean	146.5	144.8	41.8	38.0	19.2	18.0	40.0	38.9	11.6	10.3*	18.9	18.5	46.4	46.0	35.0	34.7	31.3	30.4	42.7	41.8
(females = 20,	Std. Dev.	8.5	6.6	11.1	7.0	3.8	2.5	3.6	3.6	1.9	1.8	1.9	1.7	3.1	2.6	2.3	2.1	4.6	3.6	3.5	2.9
males = 19,	Min.	131.0	134.0	25.5	28.7	14.9	14.6	34.0	28.6	7.7	7.7	16.0	15.8	40.6	41.5	31.5	30.5	23.8	25.0	35.2	37.0
age = 8–10)	Max.	167.0	157.0	64.2	50.8	26.4	23.2	49.2	44.6	14.6	15.9	22.8	22.6	52.2	49.9	38.3	38.3	37.4	36.6	53.5	47.4
	5 %tile	131.2		25.7		14.9		34.0		7.8		16.0		40.7		31.5		23.9		35.4	
	95 %tile	166.5		63.9		26.4		49.0		14.6		22.8		52.1		38.3		37.4		53.1	
6th 9th grade	Mean	156.7	157.6	48.0	47.3	19.4	18.7	41.7	43.0*	12.3	11.5	20.4	19.3	51.3	50.5	39.6	38.3	33.6	32.7	45.7	45.0
(females = 38,	Std. Dev.	9.1	11.5	11.8	11.5	3.8	2.0	2.3	2.7	2.1	1.3	3.9	2.0	4.6	3.8	4.1	3.1	4.3	3.7	3.2	3.5
males = 30,	Min.	138.0	139.0	30.4	30.5	12.8	14.9	35.9	38.4	9.9	9.0	5.1	14.4	36.5	45.8	25.3	34.6	26.5	24.3	40.7	39.8
age = 9–14)	Max.	174.0	184.0	82.7	80.5	30.4	23.8	47.4	49.3	21.3	14.6	28.5	23.0	59.7	60.2	47.6	46.3	44.3	40.6	51.3	54.0
	5 %tile	139.0	141.2	31.4	31.9	13.1	15.5	37.1	38.8	10.1	9.3	13.5	15.8	43.7	45.9	34.2	34.7	27.1	26.0	40.7	40.0
	95 %tile	171.2	181.8	72.8	73.8	26.7	22.8	45.4	49.2	15.9	14.3	27.1	23.0	59.2	58.6	46.8	44.6	41.5	40.5	51.0	53.2

Percentiles are calculated for sample size > 20. *$p < 0.05$, **$p < 0.01$.

Table 5
Anthropometric characteristics of secondary school female and male students

Secondary school		Body height (cm)		Body mass (kg)		BMI (kg/m^2)		Popliteal height (cm)		Thigh thickness (cm)		Elbow height sitting (cm)		Shoulder height sitting (cm)		Subscapular height sitting (cm)		Hip width (cm)		Buttock popliteal height (cm)	
		female	male	female	male	female	male	female	male	female	male	female	male	female	male	female	male	female	male	female	male
1st grade	Mean	163.5	174.6	59.6	72.2	22.5	23.6	40.6	45.2*	12.7	15.2	23.8	23.1	56.8	58.1	44.7	44.7	34.8	37.0*	47.7	51.0
(females = 2,	Std. Dev.	17.7	7.6	5.2	15.1	2.9	4.3	6.0	2.5	0.7	2.1	3.6	2.7	2.0	3.2	1.0	2.8	0.6	3.9	6.0	3.2
males = 47,	Min.	151.0	159.0	55.9	47.7	20.4	17.7	36.3	40.4	12.2	10.0	21.2	17.5	55.4	51.0	44.0	37.8	34.4	29.4	43.4	44.4
age = 14–16)	Max.	176.0	189.0	63.2	114.1	24.5	35.1	44.8	51.3	13.2	19.4	26.3	28.4	58.2	65.4	45.4	49.7	35.2	47.2	51.9	57.9
	5 %tile		161.0		49.7		18.1		40.5		11.8		18.3		52.1		39.2		31.3		46.1
	95 %tile		187.6		106.7		32.5		50.2		18.5		28.0		64.6		49.5		46.0		56.0
2nd grade	Mean	167.0	177.7*	54.2	70.6	19.4	22.4	43.5	45.9	12.6	15.2	26.3	22.7*	60.6	58.8	47.0	46.3	39.6	35.8	49.1	51.4
(females = 2,	Std. Dev.	1.4	6.5	2.3	12.5	1.1	3.9	2.1	2.0	0.1	1.8	2.3	2.4	1.7	2.5	0.7	3.2	0.3	2.9	2.2	2.2
males = 31,	Min.	166.0	165.0	52.6	53.1	18.6	17.5	42.0	42.2	12.5	12.1	24.6	16.6	59.4	53.4	46.5	39.0	39.4	30.7	47.6	47.7
age = 15–17)	Max.	168.0	190.0	55.8	105.0	20.2	32.8	45.0	50.6	12.6	19.8	27.9	27.1	61.8	63.9	47.5	53.0	39.8	42.3	50.6	55.5
	5 %tile		165.0		53.2		17.9		42.2		12.6		17.4		53.9		39.8		30.8		47.9
	95 %tile		188.2		100.1		31.9		50.3		19.2		26.6		63.2		51.8		41.8		54.8
3rd grade	Mean	171.0	180.6	62.7	72.8	21.4	22.3	45.0	46.7	14.1	15.3	24.2	23.9	58.1	60.5	43.3	46.4	38.0	36.1	51.7	52.0
(females = 1,	Std. Dev.		5.0		11.7		3.3		2.5		1.9		2.7		3.3		2.9		2.3		2.7
males = 10,	Min.		173.0		54.3		16.9		42.6		11.6		17.6		53.6		40.5		31.3		48.9
age = 16–18)	Max.		188.0		93.1		26.7		50.9		18.7		26.4		65.1		49.4		39.4		57.0
	5 %tile																				
	95 %tile																				
4th grade	Mean		181.1		81.8		25.0		46.3		16.4		25.2		61.8		46.7		38.0		52.0
(females = /,	Std. Dev.		5.8		17.7		5.7		2.3		1.9		2.2		1.9		2.7		3.7		2.4
males = 39,	Min.		168.0		55.0		17.0		41.1		12.8		20.5		57.7		40.9		30.7		45.4
age = 17–19)	Max.		192.0		139.5		45.0		51.0		21.0		29.5		64.5		52.8		49.9		56.7
	5 %tile		172.0		57.5		17.8		42.0		13.5		21.4		58.6		42.7		33.2		47.7
	95 %tile		190.0		124.0		38.1		50.0		20.0		28.6		64.5		52.1		44.6		56.6
5th grade	Mean		179.4		71.4		22.1		45.6		14.7		24.7		61.3		48.3		35.7		51.7
(females = /,	Std. Dev.		12.2		14.2		2.9		1.4		1.9		2.2		3.5		3.0		2.8		2.1
males $n = 7$,	Min.		157.0		56.8		18.2		43.6		12.6		21.4		56.1		43.5		31.9		48.1
age = 18–20)	Max.		189.0		95.0		27.2		47.3		17.0		27.6		63.9		50.9		40.0		54.0
	5 %tile																				
	95 %tile																				

Percentiles are calculated for sample size > 20. $^{*}p < 0.05$, $^{**}p < 0.01$.

Table 6
Anthropometric characteristics of university female and male students

University		Body height (cm)		Body mass (kg)		BMI (kg/m^2)		Popliteal height (cm)		Thigh thickness (cm)		Elbow height sitting (cm)		Shoulder height sitting (cm)		Subscapular height sitting (cm)		Hip width (cm)		Buttock popliteal height (cm)	
		female	male	female	male	female	male	female	male	female	male	female	male	female	male	female	male	female	male	female	male
1st grade	Mean	165.7	180.5**	61.0	78.1**	22.2	24.0**	41.9	46.2**	13.8	16.2**	24.3	24.3	57.7	60.8**	45.8	47.2*	39.9	40.0	48.3	51.7**
(females = 63,	Std. Dev.	6.3	5.2	8.3	9.6	2.8	2.5	2.0	1.8	1.5	1.6	2.4	2.8	2.6	2.6	2.5	2.7	2.8	2.4	3.0	2.2
males = 27,	Min.	153.0	170.0	45.8	60.0	17.3	19.2	37.6	42.7	11.1	12.7	20.4	18.2	52.2	55.9	40.4	40.4	33.7	36.4	42.9	47.9
age = 18–22)	Max.	181.0	194.0	95.5	91.2	35.5	28.5	47.5	51.0	19.9	19.3	30.6	28.9	65.6	65.4	52.6	51.3	51.9	45.2	59.5	55.9
	5 %tile	156.0	171.6	50.9	60.0	19.1	19.7	38.4	43.0	11.6	13.3	20.4	18.6	53.5	56.2	41.0	41.3	36.4	36.6	43.8	47.9
	95 %tile	177.6	193.6	76.7	91.2	27.9	28.2	45.0	50.7	16.4	19.2	29.0	28.3	62.4	65.3	49.9	50.9	45.5	44.6	53.9	55.6
2nd grade	Mean	165.9	180.3**	63.0	75.4**	22.9	23.2	41.6	46.4**	14.0	14.8	24.7	25.6	57.6	60.8**	45.8	47.3	40.8	39.1	48.1	50.3*
(females = 32,	Std. Dev.	6.5	4.4	8.9	8.2	3.0	1.9	2.2	2.4	1.4	1.5	2.1	3.0	2.0	3.0	3.3	2.8	2.7	2.1	3.1	1.7
males = 12,	Min.	157.0	173.0	50.7	64.8	16.4	19.8	38.3	41.7	11.5	12.6	21.9	21.9	53.5	56.7	41.2	40.7	37.7	35.8	41.1	46.4
age = 19–35)	Max.	184.0	186.0	92.5	86.5	30.6	25.5	46.2	50.5	17.2	16.8	29.7	31.9	62.9	65.9	56.4	49.8	48.6	42.7	54.1	52.2
	5 %tile	157.0		50.8		17.8		38.4		12.0		22.1		53.9		41.4		37.8		42.2	
	95 %tile	179.5		85.2		30.3		45.8		17.0		29.1		61.8		55.2		47.4		53.5	
3rd grade	Mean	167.1	184.0**	57.7	81.2**	20.6	23.9**	42.8	47.2**	13.8	16.8**	24.0	25.4	57.6	61.7*	45.5	47.8	40.0	40.3	48.7	53.0**
(females = 9,	Std. Dev.	4.9	7.7	5.1	9.9	1.0	1.1	1.8	3.1	0.9	1.9	2.2	1.6	2.6	2.9	2.9	2.7	2.4	1.5	1.7	2.1
males = 5,	Min.	159.0	172.0	51.5	67.3	19.3	22.7	39.2	42.8	12.8	14.6	20.6	23.4	54.2	58.2	42.5	44.4	37.3	39.0	45.6	49.4
age = 20–22)	Max.	173.0	191.0	65.0	93.6	22.2	25.7	46.0	50.2	15.5	19.5	27.8	27.4	61.6	65.6	50.2	50.9	44.4	42.8	50.6	55.1
	5 %tile																				
	95 %tile																				

Percentiles are calculated for sample size > 20. *$p < 0.05$, **$p < 0.01$.

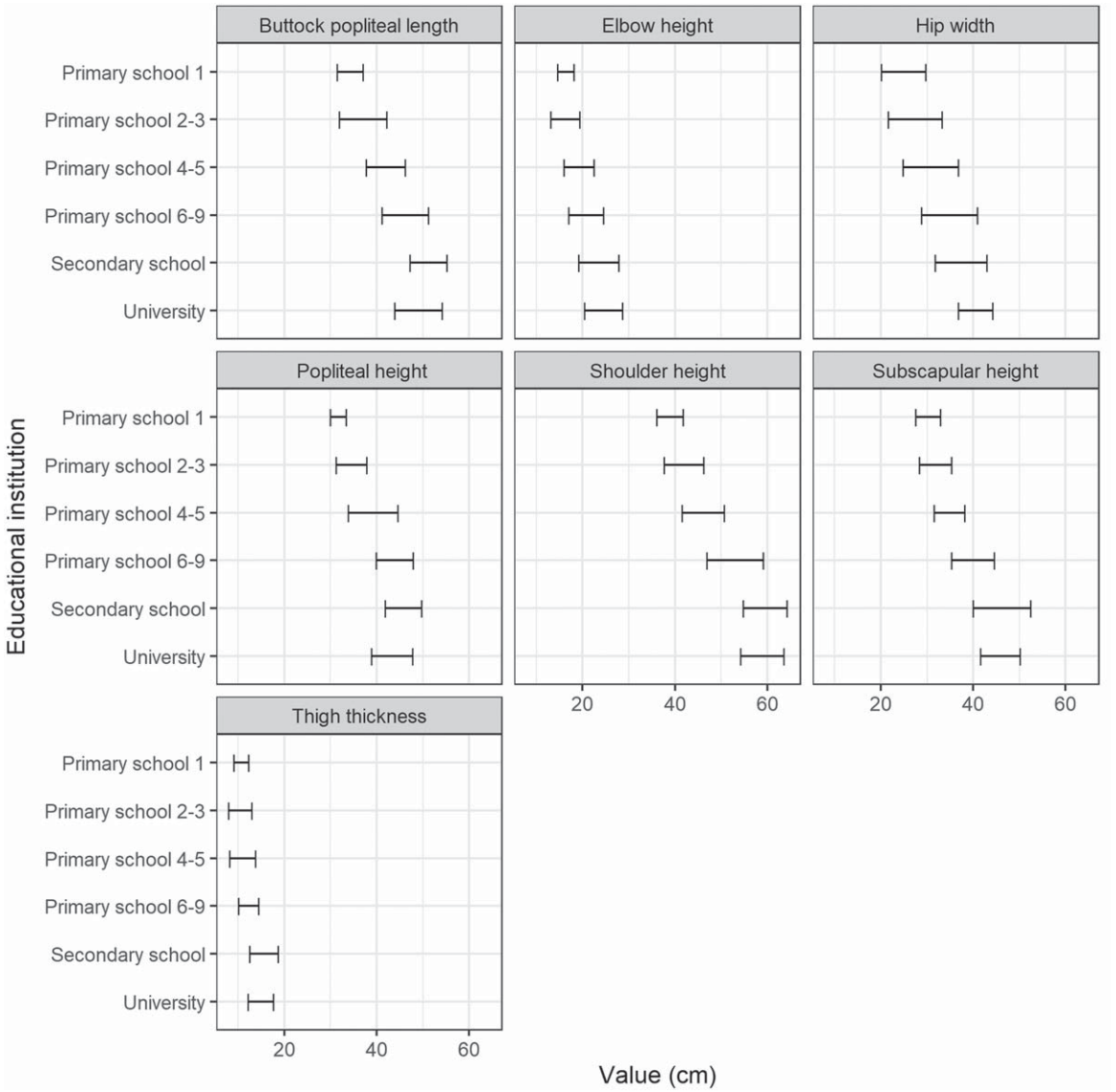

Fig. 2. The 5th and 95th percentiles of the students' measured body dimensions.

females (15.8%–25.0%) while in higher grades, the seat depth mismatch became more noticeable among females (26.3%) in comparison with males (23.3%). Backrest height was suitable for all students from the 1st grade and unsuitable and too high for the majority of students from higher grades of primary school. Seat width and seat to desk clearance were suitable for all primary school students, except for three and one student from 6th to 9th grade, respectively.

3.3.2. Secondary school

In secondary school, all classrooms are furnished with the same type of school furniture and students shuffle among the classrooms. Desk height was unsuitable and mainly too high for about half of all secondary school students (54.0%). The desk height mismatch was twice as large among students from lower grades (1st and 2nd) compared with students from higher grades (3rd–5th). The seat height was unsuitable and too high for approximately one fifth of all students (14.0%–20.7%). Again, the mismatch was more pronounced among students from lower grades compared to students from higher grades and twice as higher among females compared to males. On the other hand, the seat depth mismatch was evidently higher among male (38.5%–41.1%) compared

Table 7
Effect of gender, grade, and their interaction on body dimensions of students in primary school, secondary school, and university

Institution	Body height		Body mass		BMI		Popliteal height		Thigh thickness		Elbow height sitting		Shoulder height sitting		Subscapular height sitting		Hip width		Buttock popliteal length	
	p	*ηp2*	*p*	*ηp2*	*p*	*ηp2*	*p*	*ηp2*	*p*	*ηp2*	*p*	*ηp2*	*p*	*ηp2*	*p*	*ηp2*	*p*	*ηp2*	*p*	*ηp2*
Primary school																				
Gender	0.15	0.02	0.56	0.00	0.83	0.00	0.14	0.02	0.14	0.02	0.08	0.02	0.63	0.00	0.47	0.00	0.95	0.00	0.95	0.00
Grade	0.00**	0.75	0.00**	0.51	0.02*	0.12	0.00**	0.74	0.00**	0.21	0.00**	0.33	0.00**	0.72	0.00**	0.68	0.00**	0.46	0.00**	0.75
Gender * Grade	0.12	0.09	0.39	0.06	0.48	0.05	0.12	0.09	0.21	0.08	0.54	0.05	0.46	0.05	0.21	0.08	0.43	0.06	0.09	0.09
Secondary school																				
Gender	0.00**	0.07	0.08	0.02	0.46	0.00	0.01*	0.05	0.03*	0.04	0.21	0.01	0.63	0.00	0.57	0.00	0.49	0.00	0.14	0.02
Grade	0.08	0.06	0.03*	0.08	0.12	0.05	0.23	0.04	0.03*	0.08	0.00**	0.11	0.00**	0.17	0.14	0.05	0.10	0.06	0.51	0.02
Gender * Grade	0.99	0.00	0.94	0.00	0.91	0.00	0.54	0.01	0.84	0.00	0.43	0.01	0.37	0.02	0.54	0.01	0.24	0.02	0.66	0.01
University																				
Gender	0.00**	0.46	0.00**	0.36	0.00**	0.06	0.00**	0.39	0.00**	0.20	0.18	0.01	0.00**	0.20	0.01*	0.05	0.46	0.00	0.00**	0.17
Grade	0.39	0.01	0.98	0.00	0.58	0.01	0.28	0.02	0.08	0.04	0.26	0.02	0.85	0.00	0.98	0.00	0.97	0.00	0.15	0.03
Gender * Grade	0.80	0.00	0.12	0.03	0.18	0.02	0.83	0.00	0.03*	0.05	0.52	0.01	0.79	0.00	0.88	0.00	0.24	0.02	0.41	0.01

*$p<0.05$, **$p<0.01$.

to female (0.0–25.0%) students. Space under the desk was too small for the majority of students from all grades. The backrest was suitable for all secondary school students. The differences between males and females should be regarded with caution due to the notable gender imbalance among secondary school students.

3.3.3. University

In university, the majority of classrooms are furnished with the same type of school furniture and students shuffle among the classrooms. Desk height was unsuitable for almost half of students (48.0%). Of these, it was too high for 91.5%. The desk height mismatch was more evident among female (51.9%) compared to male (38.6%) students. Similarly, the seat height mismatch was four times higher among female (67.3%) in comparison with male students (15.9%). On the other hand, the seat depth was more unsuitable for males (54.5%) than for females (16.3%). The seat width was too narrow for two (1.9%) female students, the backrest and seat to desk clearance were acceptable for most of the students.

4. Discussion

To the best of our knowledge, this was the first study to comprehensively address the student-furniture mismatch in Slovenian primary school, secondary school, and university. Confirming our hypotheses, the student-furniture mismatch was present in all educational institutions with the highest levels of mismatch for the desk (48.0%–100.0%) and seat (18.0%–94.6%) height. Space for legs under the desk was the worst in secondary school, and the backrest was the most unsuitable in higher grades of primary school. Seat depth mismatch was present across all educational institutions (23.1%–40.4%).

Body measurements varied substantially within primary school, secondary school, and university students. Although body dimensions are supposed to increase with age, body height and popliteal height were higher among secondary school students compared to university students (Table 2). When comparing the 5th and 95th percentile values, the differences were less noticeable. This could be explained by predominantly male students in secondary school and mainly female university students. As already mentioned, gender imbalance among secondary school and university students is a limitation of this study. On the other hand, this reflects the

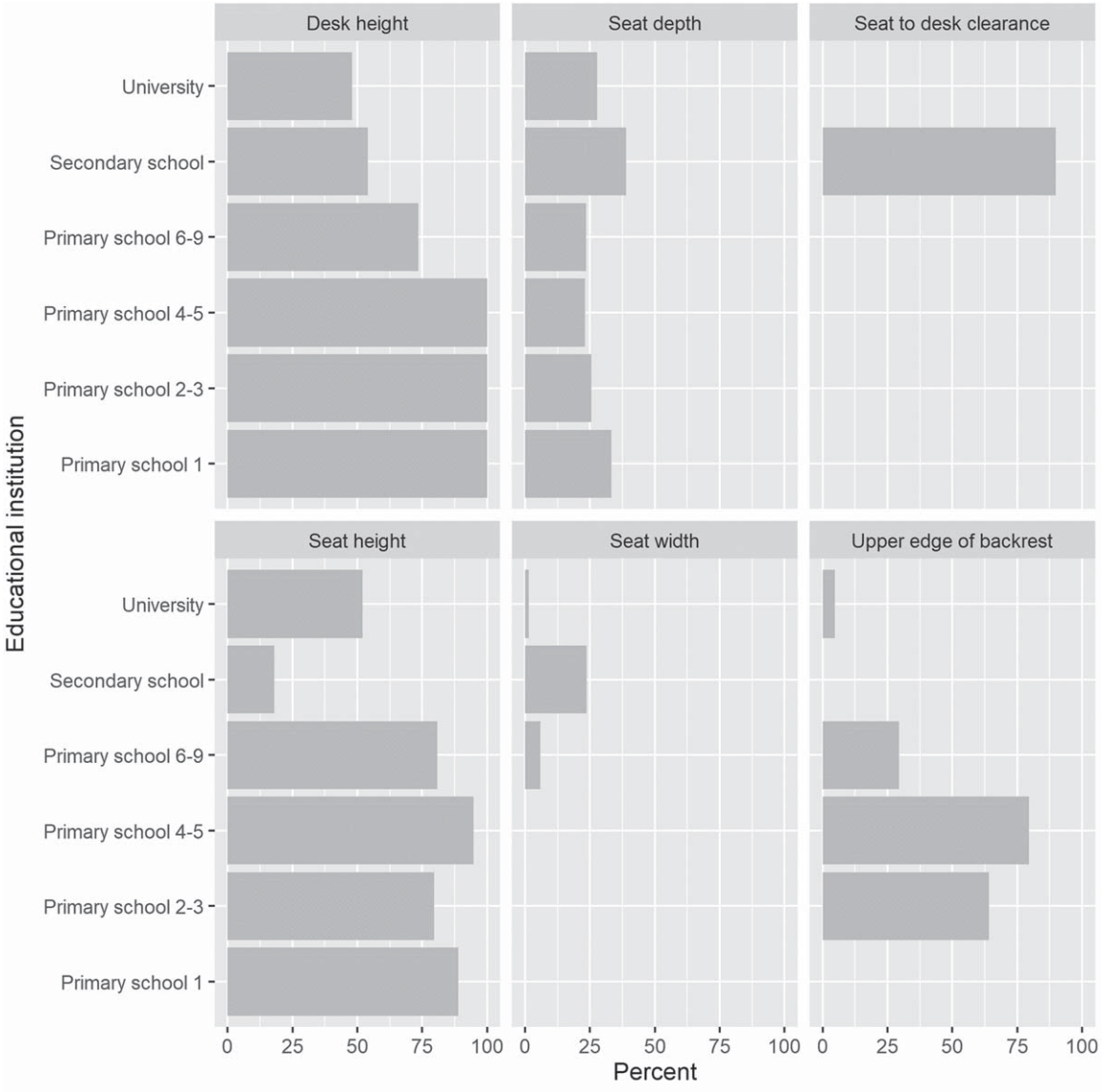

Fig. 3. Student-furniture mismatch. Students are grouped based on the type of the school furniture.

actual situation in Slovenian educational institutions included in this study. The results of this study suggest that students in secondary school may not necessarily have smaller body dimensions than students at university. Moreover, students from later grades in primary school, secondary school, and university may have, to some extent, comparable body dimensions.

Significant differences in all body dimensions were observed among primary school students of different grades and only few differences between male and female primary school students were observed (Table 7). This suggests that in primary school the same type of furniture can be used by boys and girls in the same classroom. In the last grades of primary school, differences in body dimensions and consequently also the mismatch becomes more apparent among genders, indicating that different sizes of furniture are needed.

In secondary school, body dimensions also differed among students of different ages. Specifically, the mismatch for desk and seat height was almost twice as high in younger students from 1st and 2nd grade compared with older secondary school students from 3rd to 5th grade. Currently, the same type of furniture is used by all secondary school students, however, the results of this study suggest at least

Table 8
Match and mismatch percentages by grade level and gender

		Seat height			Seat width			Seat depth			Upper edge of backrest			Seat to desk clearance			Desk height		
		Total (%)	Female (%)	Male (%)	Total (%)	Female (%)	Male (%)	Total (%)	Female (%)	Male (%)	Total (%)	Female (%)	Male (%)	Total (%)	Female (%)	Male (%)	Total (%)	Female (%)	Male (%)
Primary school	1st grade																		
	Match	11.1	0.0	20.0	100.0	100.0	100.0	66.7	100.0	60.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	0.0	0.0
	Mismatch	88.9	100.0	80.0	0.0	0.0	0.0	33.3	0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	100.0
	2nd-3rd grade																		
	Match	20.5	26.3	15.0	100.0	100.0	100.0	74.4	84.2	65.0	35.9	31.6	40.0	100.0	100.0	100.0	0.0	0.0	0.0
	Mismatch	79.5	73.7	84.5	0.0	0.0	0.0	25.6	15.8	35.0	64.1	68.4	60.0	0.0	0.0	0.0	100.0	100.0	100.0
	4th – 5th grade																		
	Match	5.1	10.0	0.0	100.0	100.0	100.0	76.9	80.0	73.7	20.5	25.0	15.8	100.0	100.0	100.0	0.0	0.0	0.0
	Mismatch	94.6	90.0	100.0	0.00	0.0	0.0	23.1	20.0	26.3	79.5	75.0	84.2	0.0	0.0	0.0	100.0	100.0	100.0
	6th–9th grade																		
	Match	19.1	5.3	16.7	94.1	92.1	100.0	76.5	73.7	76.7	70.6	60.5	43.3	100.0	97.4	100.0	26.5	26.3	6.7
	Mismatch	80.9	94.7	83.3	5.9	7.9	0.0	23.5	26.3	23.3	29.4	39.5	56.7	0.0	2.6	0.0	73.5	73.7	93.3
Secondary school	1st–5th grade																		
	Match	82.0	60.0	82.8	76.3	60.0	77.6	61.2	80.0	60.4	100.0	100.0	100.0	10.1	60.0	9.0	46.0	60.0	45.5
	Mismatch	18.0	40.0	17.2	23.7	40.0	22.4	38.8	20.0	39.6	0.0	0.0	0.0	89.9	40.0	91.0	54.0	40.0	54.5
	1st–2nd grade																		
	Match	79.3	50.0	80.8	76.8	50.0	78.2	62.2	75.0	61.5	100.0	100.0	100.0	11.0	75.0	7.7	32.9	75.0	30.8
	Mismatch	20.7	50.0	19.2	23.2	50.0	2.8	37.8	25.0	38.5	0.0	0.0	0.0	89.0	25.0	92.3	67.1	25.0	69.2
	3rd–5th grade																		
	Match	86.0	100.0	85.7	75.4	100.0	75.0	59.6	100.0	58.9	100.0	100.0	100.0	8.8	0.0	8.9	64.9	0.0	66.1
	Mismatch	14.0	0.0	14.3	24.6	0.0	25.0	40.4	0.0	41.1	0.0	0.0	0.0	91.2	100.0	91.1	35.1	100.0	33.9
University	1st–3rd grade																		
	Match	48.0	32.7	84.1	98.6	98.1	100.0	72.3	83.7	45.5	95.3	95.2	95.5	100.0	100.0	100.0	52.0	48.1	61.4
	Mismatch	52.0	67.3	15.9	1.4	1.9	0.0	27.7	16.3	54.5	4.7	4.8	4.5	0.0	0.0	0.0	48.0	51.9	38.6

two sizes of furniture should be used in secondary schools.

A different pattern was observed in university students where differences in body dimensions became more apparent between genders while fewer differences were observed among students of different ages. Seat height mismatch was four times higher among females compared to males and desk height mismatch was almost twice as high in females compared to male university students. Hence, also at the university level, different sizes of furniture are needed mostly due to differences between genders.

Carneiro, Gomes and Rangel [46] suggested five sizes of school furniture to accommodate students between 6 and 10 years of age. If we compare the proposed furniture dimensions with current Slovenian school furniture in primary school, we find that Slovenian furniture is larger, especially the seat height. This discrepancy is also reflected in mismatch calculations, which showed that the seat height was too high for the majority (79.5–95.9%) of 1st to 5th graders. In our study, the seat and desk heights were the most unsuitable for students at all levels of education. This is comparable with the findings from Agha [19] who found a mismatch up to 99% for seat and desk height among primary school students, observations by van Niekerk et al. [47] who reported seat height to be unsuitable for the majority of secondary school students, and results by Baharampour et al. [24] who found a mismatch higher than 90% for seat and desk height among university students. In our study, seat depth was too shallow for 23% to 38% of the student population, indicating that adjustable seat depth is desired. Bahrampour et al. [48] suggested that seat depths could be based on the fifth percentile of the study population, which to some extent contradicts the mismatch calculations. The rate of seat to desk clearance mismatch was the highest in secondary school, which can be explained by the fact that only desks in secondary school had iron shelves embedded under the desk. Shelves embedded under the desk are practical for book storage but take up space for free movement of the legs. A modified desk design should be considered to provide enough space for the legs and a place to store books.

The latest standard for school furniture in Slovenia SIST EN 1729 provides different desk and chair sizes based on stature and popliteal height, which has been shown to be a more appropriate measure when defining seat height [49]. The SIST EN 1729 standard is partly suitable to Slovenia's population; especially desk and seat height are often too high. Similarly, Guelfi et al. [50] reported furniture conforming to EN 1729 to be too large for an average Italian student. Nevertheless, the results of our study suggest that the issue is not entirely in the standard requirements. When comparing students' measured stature and popliteal height with the standard size mark of the furniture, the size mark of the furniture used in the classrooms is generally too large. Due to the anthropometric variability of students attending the same grade, at least two size marks of furniture should be available in the classroom. For example, in the 1st grade of primary school, school furniture in size marks 2 and 3 should be available to provide suitable furniture to all students. Moreover, different size marks of furniture are recommended based on measured stature height or popliteal height. For example, in the 2nd and 3rd grade of primary school furniture size marks 3 and 4 are recommended based on the stature height, while size marks 2–5 are recommended based on the popliteal height. To meet the requirements of the heterogeneous anthropometric dimensions of students, using different size marks of furniture in the same classroom should be considered and regular popliteal height measurements should be performed to ensure that appropriate school furniture is used [49]. However, changing and moving school furniture between classrooms could be time-consuming and inconvenient.

SIST EN 1729 also includes requirements for adjustable chairs and desks which should cover at least two size marks. If the furniture would follow these requirements, the mismatch could be decreased. Also, adjustable school desks are a more convenient way of setting the appropriate seating height for the students. As suggested by several authors, adjustable school furniture (chairs and/or desks) can prevent poor posture and ensure the well-being of students in the classroom [47, 50, 51]. Previous research has suggested adjustable school furniture solutions [52, 53], while its regular use in Slovenian schools is not yet common [15]. Thus, further development and effort are needed to achieve long-term implementation.

Dimensional compatibility is only one of several factors that influence the health and well-being of the students while in the classroom. Focusing only on micro-ergonomics, such as the suitability of school furniture, may have limited impact. To mitigate the negative effects of classroom sitting, enhancing physical activity levels among students in schools by implementing in-class activity breaks, physical education classes, active transport before and after school, can be a successful strategy [54,

55]. Moreover, a more comprehensive evaluation of the indoor school environment as a whole is needed. In this context, policy-based support could help to ensure healthy indoor environments for students in schools. We believe it is worthy to educate students about the importance of good sitting posture and frequent sitting interruptions as well as emphasize the importance of restorative indoor environments in order to counterbalance the negative health effects of remaining seated for long periods of time. Finally, it is essential to ensure teachers are prepared to accept changes in the school environment as they are the ones who encourage and motivate students to change existing habits or introduce new ones.

4.1. Limitations

The study's main limitation is that our sample was a convenience sample, rather than nationally representative. For primary school, the sample size was relatively small, and for secondary school, the sample was gender-unbalanced. Furthermore, only three schools were included in our study (one primary, one secondary and one university), and there is a possibility that school furniture differs between Slovenian schools. Despite the limitations, this is, to best of our knowledge, the first study aiming to comprehensively evaluate school furniture suitability in Slovenia.

5. Conclusion

The results of this study provide useful insight into the ergonomic suitability of school furniture in Slovenian primary school, secondary school, and university. A high student-furniture mismatch has been observed at all educational institutions. Desk and seat height were the most inappropriate furniture dimensions and were in general too high for the students. The mismatch for desk height decreased from 100.0% at primary school to 48.0% at university. Similarly, seat height mismatch was the most evident in primary school (89.7%–94.6%), lower at university (52.0%) and the lowest in secondary school (18.0%). Seat depth mismatch was comparable among all groups, ranging from 23.1% to 40.4%, and was in general more pronounced in males. Seat to desk clearance was the most evident among secondary school students. Backrest height was too high for the majority of primary school students (except for 1st graders), and acceptable in secondary school and university.

The results showed anthropometric variability among students of different ages, gender, and educational levels. Differences among students of different ages were the most apparent in primary school students, while at the university level, differences in body dimensions became more evident between male and female students. Students from secondary school were on average taller and had higher popliteal height compared with university students, indicating that to some extent, body dimensions among students from different educational levels can be comparable. To improve the suitability of school furniture we suggest adjustable school furniture, covering at least two size marks, to be introduced in schools jointly with restorative indoor environments to provide ergonomic learning conditions and further enhance the comfort and well-being of students in the classroom.

Acknowledgments

The authors gratefully acknowledge the European Commission for funding the InnoRenew CoE project (Grant Agreement #739574) under the Horizon2020 Widespread-Teaming program and the Republic of Slovenia (Investment funding of the Republic of Slovenia and the European Union of the European regional Development Fund). The authors would like to acknowledge the financial support by the Slovenian Research Agency through the infrastructure grant no. IO-0035.

Conflict of interest

The authors declare no conflict of interest.

Supplementary materials

The appendix is available from https://dx.doi.org/10.3233/WOR-210487.

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