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Changes in Somatic Indicators, Body Posture and Health-Oriented Fitness among Younger School-Age Female Pupils

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Abstract: *Background and Aim of Study: Currently, we are observing a worsening trend in the field of health-oriented fitness and postural health of the school population. The aim of the research was to compare and expand knowledge in the areas of monitoring somatic changes, indicators of health-oriented fitness, motor performance, and body posture among 10-year-old female school populations. Material and Methods: The sample consisted of Σn=292 female pupils, with n=150 from 2012 and n=142 from 2022 at the elementary school in Žilina (ZA), Slovakia. An ex post facto study was applied. Standardized methods of measurement and testing applicable for school practice were used to obtain data. Differences between groups of female pupils were examined using the Kruskal-Wallis H-test and the Mann-Whitney U-test. To determine the effect size and measure the difference in average values, Cohen's d and r were used. The differences found were evaluated at the (p<0.05) level of statistical significance. Results: When comparing the average body weight of female pupils from ZA in 2012 and 2022, we found a significant difference (p<0.05) (H=4.87, p=0.02733) in favor of female pupils from 2012. The same finding in favor of female pupils from 2012 was recorded when comparing the average body mass index (BMI) (H=4.8182, p=0.02816), as well as in evaluating the average health-oriented fitness using the Ruffier test (H=13.1965, p=0.00028). The Beep test was also used to evaluate the endurance abilities of female pupils, where current ZA female pupils in 2022 showed significantly worse results (H=5.752, p=0.01647). Similarly, we also observed significant (p<0.05) worse findings in overall body posture among female pupils from ZA in 2022. Conclusion: On the basis of our findings, we consider the current state of body weight, posture, health-oriented physical fitness and endurance skills in younger school-aged girls to be unsatisfactory and health-threatening. It is necessary to further deal with the stated facts and look for preventive measures. These findings indicate a declining and deteriorating trend in health-oriented fitness in relation to body weight, body posture, and endurance abilities.*

Keywords: *body posture; body weight; endurance abilities; health-oriented fitness, younger school age.*

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Introduction

Obesity, overweight, and incorrect body posture are currently considered one of the phenomena that triggers chronic non-infectious diseases. They have become a global epidemic problem with increasing prevalence worldwide in all age groups (Sahoo et al., 2015; Bendíková, 2017). An important factor in prevention remains exceeding energy expenditure over energy intake. Childhood obesity poses a more serious health risk than obesity in adulthood. Preventing health problems from overweight and obesity in children should not be addressed only at the family level but also at schools, healthcare systems, and government organizations, as it is a societal problem (Di Cesare et al., 2019).

Somatic growth is a certain indicator of the overall health status of individuals and the entire population, both in the past and present (Wesley et al., 2016). Anthropometric parameters obtained in the last three decades based on measurements of populations aged 8 to 20 years indicate an acceleration of growth and development in children (Moravec et al., 1996; Rozim, 2004; Podstawski & Borysławski, 2012).

In Slovakia, we have observed a rising trend of chronic non-infectious diseases and health disorders among school populations in the past two decades. Several domestic and foreign researchers point to the unfavorable state of postural health among school populations, with the incidence of incorrect body posture (Nemček, 2016; Neiva et al., 2017; Bendíková et al., 2018; Wilczyński & Bienik, 2018; Kolarova et al., 2019; Leskinen et al., 2020; Bendíková et al., 2020; Lenková, 2021; Vasilišinová & Lenková, 2021; Yang et al., 2022).

Physical activity is one of the key needs of younger school-aged children, which is significantly restricted after their enrollment in school, as evidenced by several studies (Müller et al., 2019). Current knowledge and research confirm that health-oriented physical fitness cannot be adequately developed without regular physical activity. For this reason, health-oriented fitness must be understood as part of a comprehensive physical activity program that must aim at systematic education of school populations and acquisition of knowledge and skills in physical and health literacy (Sallis, 2014; Bendíková, 2016; Bendíková & Smoleňáková, 2018).

In connection with the above facts, the most important contribution in the field of physical education and sports is currently achieving an optimal level of health-oriented physical fitness among school populations as a means of preventing physical and mental health. Fitness affects health status, and therefore several authors refer to it as health-oriented fitness (Bunc,

1998). Health-oriented fitness is the level of individual fitness required for a healthy and active lifestyle (Bendíková, 2017). The assessment of health-oriented fitness using standardized methods allows for determining its level in school-aged children and identifying critical groups or individuals from a health perspective in a given population.

The aim of the research was to compare and expand knowledge in the areas of monitoring somatic changes, indicators of health-oriented fitness, motor performance, and body posture among 10-year-old female school populations.

Material and Methods

Participants

The study group consisted of (Σn=292) female students from primary schools in Žilina. We compared (n=150) female students from the year 2012, who were younger in age group, with an average age of (10.69±0.42 years), to the group of female students (n=142) observed in the year 2022, who were also younger in age group, with an average age of (10.42±0.31 years). Table 1 presents the primary characteristics of the group of female students from primary schools in Žilina.

Table 1 Characteristics of female students from primary schools in Žilina (n=292)

Group	Factors	Height [cm]	Weight [kg]	BMI [index]	Ruffier test [index]
Students in Žilina (2012) n=150	n	150	150	150	150
	x	146.39	36.72	17.05	14.08
	sd	13.47	15.03	7.06	6.64
	min.	127.0	25.0	10.4	7.0
	max.	161.0	56.5	28.1	36.4
	$R_{max.-min.}$	34.0	31.5	17.7	29.4
	x_m	146.0	34.00	16.39	13.60
Students in Žilina (2022) n=142	n	142	142	142	142
	x	148.37	42.92	20.63	17.91
	sd	14.99	15.61	7.82	5.46
	min.	131,0	29.0	11.2	12.4
	max.	166.0	63.0	30.5	27.0
	$R_{max.-min.}$	35.0	34.0	19.2	14.6
	x_m	148.50	42.45	20.21	17.80

Legend: n – sample size, x – arithmetic mean, s – standard deviation, min. – minimum value, max. – maximum value, $R_{max.-min.}$ – range, x_m – median.

Measurements and Procedure

In the research study of younger female students from primary schools in the city of Žilina, we evaluated primary somatic characteristics (height, weight, and BMI).

In terms of assessing body posture, we applied a standardized method for physical education practice according to Thomas-Klein mod. Mayer (Bendíková, 2017), which evaluates individual body areas (I. Head and neck posture, II. Chest (shape), III. Abdomen and pelvic inclination, IV. Spine curvature, V. Frontal body posture) and subsequently systematizes them into a qualitative level: I. Correct body posture - 5 points, II. Good (almost correct) body posture - 6 – 10 points, III. Bad body posture -11 – 15 points, IV. Incorrect body posture - 16 – 20 points.

To assess physical fitness, we used standardized tests for school practice: the Ruffier, endurance was evaluated using the Beep test and abdominal-hip muscle strength was evaluated using the sit-up test for 1 minute (Moravec et al., 1996).

Table 2 Assessment profile scale (5-level)

Level	BMI and physical fitness level	Value
Level 1	very good level	x + <1 sd
Level 2	good level	x + 1 sd
Level 3	average level	x ± 0.5 sd
Level 4	poor level	x – 1 sd
Level 5	very poor level	x – <1 sd

Legend: x – arithmetic mean, sd – standard deviation, (source: own)

To overall evaluate and assess the level of physical fitness and BMI index of female students from primary schools in the city of Žilina, we used a 5-level scoring scale (table 2, 3). The profile and criteria of individual levels were created using the method of expert subject analysis.

Table 3 Stanin's rating of the Ruffier test and BMI index for female students from primary schools in Žilina

Level	Factors Norms/values	Ruffier	BMI
Level 1	very good level/underweight	≤11.8	≤11.9
Level 2	good level/underweight	11.9–15.1	12.0–16.7
Level 3	average level/ideal weight	15.2–18.0	16.8–21.7
Level 4	poor level/overweight	18.1–21.3	21.8–26.7
Level 5	very poor level/obesity	21.4≥	26.8≥

Legend: h – weight (source: own)

Statistical analyses

To process and evaluate the obtained data, we used basic methods of exploratory analysis: (n) frequency, (x) arithmetic mean, (s) standard deviation, (min.) - minimum value, (max.) - maximum value, ($R_{max. - min.}$) - range, (x_m) - median. To determine statistical significance, we used the Kruskal-Wallis H-test, Mann-Whitney U-test, and Chi-square test for goodness of fit (χ^2). To determine effect size and the magnitude of the difference in means, we used (Cohen's d and r). The differences were evaluated at a ($p<0.05$) level of statistical significance. The resulting coefficient (d, r) was evaluated as follows: Cohen's d: d=0.20 - small effect, d=0.50 - medium effect, d=0.80 - large effect, d=1.10 - very large effect, d=1.40 and above - extremely large effect. Effect size r: r=0.10 - small effect, r=0.30 - medium effect, r=0.50 - large effect. The findings and conclusions were formulated based on a logically sound evaluation of the obtained results.

Results

When comparing the average indicators of physical development of younger school-age female students (n=292) from primary schools in Žilina in 2012 (M=146.39, SD=13.47) and 2022 (M=148.37, SD=14.99), we focused on height, weight, and body mass index (BMI).

We did not find a significant difference ($p>0.05$) in the height (Figure 1) of female students from primary schools in Žilina in 2012 and 2022 (H=1.118, p=0.29022). The difference in average height between female students from primary schools in Žilina was only (r=1.98 cm, 1.33%).

When comparing the average weight (Figure 2), a significant difference ($p<0.05$) was found in the weight of female students from primary schools in Žilina in 2012 (M=36.72, SD=15.03) and 2022 (M=42.92, SD=15.61) (H=4.87, p=0.02733) (U=38102.5, z=-2.20656, r=-0.19829).

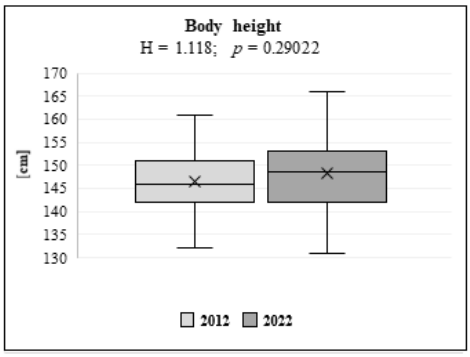


Figure 1 Comparison of height of female students from primary schools in Žilina

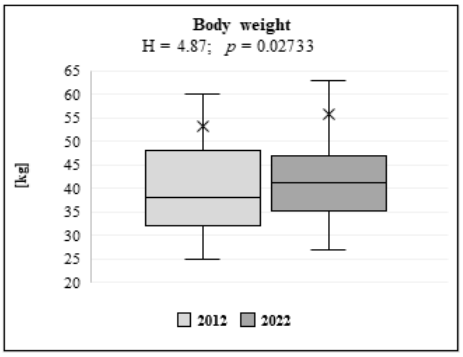


Figure 2 Comparison of weight of female students from primary schools in Žilina

When comparing the average body mass index (BMI) (Figure 3) of female students from primary schools in Žilina, a significant difference ($p<0.05$) was found ($H=4.818$, $p=0.02816$). The average difference in BMI between female students from primary schools in Žilina in 2012 ($M=17.05$, $SD=7.06$) and 2022 ($M=20.63$, $SD=7.82$) was ($r=3.58$ index units), ($U=38126.5$, $z=-2.19478$, $r=-0.23362$). The difference in the BMI of female students from primary schools in Žilina also shows a negative tendency towards an increase in body weight in the observed groups.

When evaluating the average physical fitness using the Ruffier test (Figure 4) of female students from primary schools in Žilina in 2012 ($M=14.36$, $SD=6.93$) and 2022 ($M=14.36$, $SD=6.93$), a significant difference ($p<0.05$) was found ($H=13.196$, $p=0.0028$) ($U=35196.5$, $z=-3.632$, $r=-0.630$).

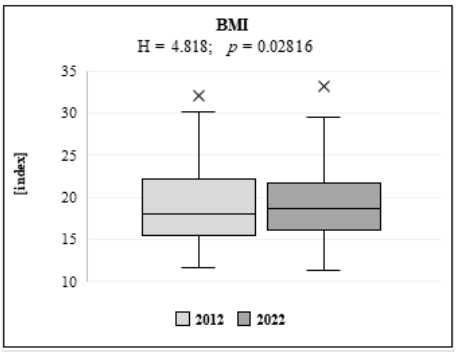


Figure 3 Comparison of BMI index of elementary school girls in Žilina

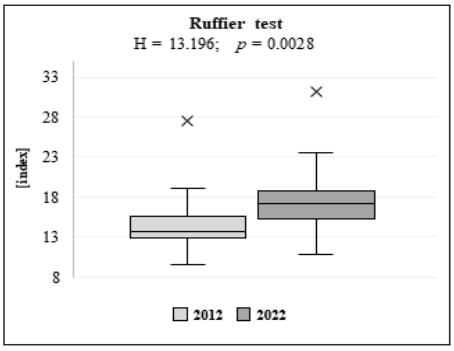


Figure 4 Comparison of physical fitness of elementary school girls in Žilina

In the Beep test (Figure 5), we evaluated the endurance abilities of female students from primary schools in Žilina. When assessing the endurance abilities of female students from primary schools in Žilina in 2012 (M=19.75, SD=17.09) and 2022 (M=13.49, SD=15.46), a significant difference ($p<0.05$) was found (H=84.752, p=0.00001) (U=37712.0, z=2.398, r=0.188).

When evaluating the strength of the abdominal and hip muscles of elementary school girls in Žilina in the lie-sit test for 1 minute (Figure 6), we did not find significant differences ($p>0.05$) (H=19.558, p=0.00021). The difference in the number of repetitions between girls from Žilina elementary school in 2012 (M=21.95, SD=14.32) and girls from Žilina elementary school in 2022 (M=19.32, SD=11.56) was lower by (r=2.63) repetitions (U=40562.5, z=0.995; r=0.100).

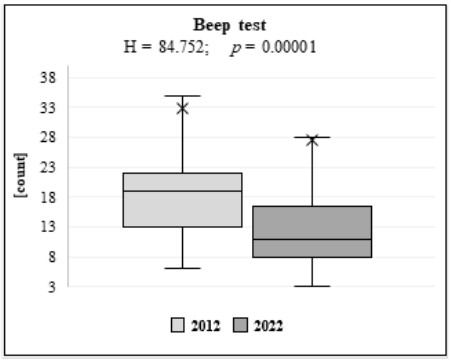


Figure 5 Comparison of endurance skills of elementary school girls in Žilina

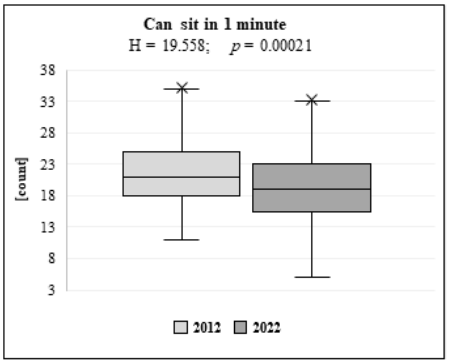


Figure 6 Comparison of abdominal-hip muscle strength of elementary school girls in Žilina

We divided the elementary school girls in Žilina into groups based on their level of physical fitness (Ruffier test index) and compared their BMI index.

Based on the Ruffier test index from the perspective of a 5-level standing scale (Figure 4, 5), we found that up to 53 girls (35.33%) from Žilina elementary school in 2012 (M=24.0, SD=2.60) and 50 girls (35.21%) from Žilina elementary school in 2022 (M=25.4 SD=7.28) reached level 5 (very poor level) of physical fitness. The BMI index values for both groups of elementary school girls in Žilina reached level 4 (overweight, 2012- M=21.8 SD=7.99, 2022- M=21.9, SD=8.50).

Level 4 (low level) of physical fitness was achieved by 50 girls (33.33%) from Žilina elementary school in 2012 (M=19.7 SD=1.88) and up

to 77 girls (54.22%) from Žilina elementary school in 2022 (M=20.15, SD=2.26). Their BMI index values for both groups of elementary school girls reached level 4 (overweight, 2012- M=23.7, SD=4.04; 2022- M=25.5 SD=4.45).

Level 3 (average level of physical fitness) for evaluating elementary school girls from Zilina (2012) was achieved by 36 girls (24.0%) (M=16.9 SD=2.22) and 11 girls (7.74%) from Žilina elementary school in 2022 (M=16.9 SD=2.42). BMI index values reached level 3 (ideal weight) for both groups of elementary school girls (M=17.0 SD=2.00; M=18.1 SD=2.62).

Only 7 elementary school girls (4.66%) from Žilina in 2012 (M=11.1 SD=1.84) and 4 girls (2.81%) from Žilina in 2022 (M=11.7, SD=0.74) achieved a good level of physical fitness. Their BMI index values for both groups of elementary school girls were in the range of 2 (underweight) (M=15.4, SD=3.08; M=16.1, SD=4.82).

Table 4 Ruffier test and BMI of elementary school girls in Žilina (2012) (n=150)

S.ch.	1. Group (n=7)		2. Group (n=14)		3. Group (n=36)		4. Group (n=50)		5. Group (n=53)	
	Ruffier	BMI	Ruffier	BMI	Ruffier	BMI	Ruffier	BMI	Ruffier	BMI
x	11.1	15.4	11.7	16.1	16.9	17.0	19.7	23.7	24.0	21.8
s	1.84	3.08	0.74	4.82	2.22	2.00	1.88	4.04	2.60	7.99
min.	9.6	13.8	11.2	13.8	15.0	15.2	18.3	19.8	21.9	13.6
max	12	18.0	12.0	18.4	18.2	18.5	21.3	28.1	26.7	28.4
$R_{min.-max.}$	2.4	4.2	0.8	4.6	3.2	3.3	3.0	8.3	4.8	14.8
p	-		-		$p<0.05$		$p<0.05$		-	

Legend: BMI - Body mass index, *p* – level of statistical significance, (source: own)

Table 5 Ruffier test and BMI of elementary school girls in Žilina (2022) (n=142)

S.ch.	1. Group (n=4)		2. Group (n=11)		3. Group (n=32)		4. Group (n=45)		5. Group (n=50)	
	Ruffier	BMI	Ruffier	BMI	Ruffier	BMI	Ruffier	BMI	Ruffier	BMI
x	11.7	16.1	16.9	18.1	19.9	20.1	20.4	25.5	25.4	21.9
s	0,74	4.82	2.42	2.62	3.18	7.73	1.34	4.45	7.28	8.50
min.	11.2	13.8	15.0	15.8	16.1	12.4	18.4	19.2	14.6	13.6
max	12.0	18.4	19.7	20.1	24.1	27.0	22.3	29.4	39.0	32.4
$R_{min.-max.}$	0.8	4.6	4.7	4.3	8.0	14.6	3.9	10.2	24.4	18.8
p	-		-		-		-		-	

Legend: BMI - Body mass index, *p* – level of statistical significance, (source: own)

The compared differences in the average values of physical fitness based on the Ruffier test among elementary school girls in Žilina (2012) (Figure 7) were significant ($p<0.05$) ($H=24.85$, $p=0.00005$).

Similarly, the differences in the average values of physical fitness were significant ($p<0.05$) among elementary school girls in Žilina (2022) ($H=10.92$; $p=0.02738$) (Figure 8).

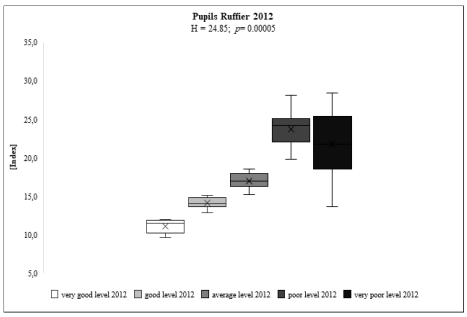


Figure 7 Comparison of physical fitness of elementary school girls in Žilina (2012)

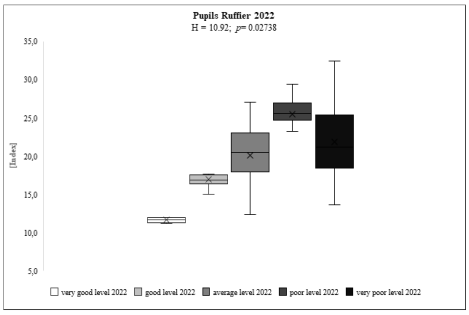


Figure 8 Comparison of physical fitness of elementary school girls in Žilina (2022)

Significant differences ($p<0.05$) ($H=10.91$; $p=0.02755$) were also observed when comparing the differences in average BMI index values among female elementary school students in Žilina (2012) (figure 9). Significant differences in average BMI index values ($p<0.05$) were also observed among female elementary school students in Žilina (2022) (figure 10) at a statistically significant level ($H=6.45$; $p=0.1677$).

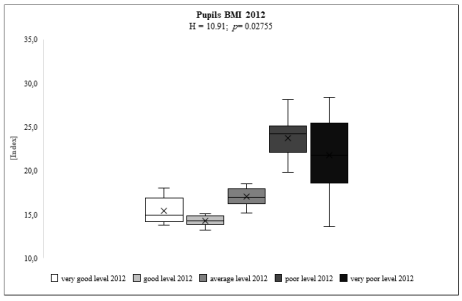


Figure 9 Comparison of BMI index of elementary school girls in Žilina (2012)

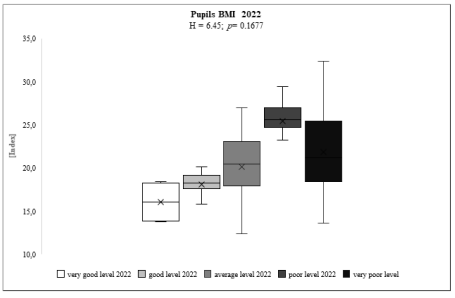


Figure 10 Comparison of BMI index of elementary school girls in Žilina (2022)

The overall assessment of body posture in younger female elementary school students in Žilina ($n=292$) in terms of comparison between the observed periods of 2012 and 2022 is presented in table 6. While in 2012, levels I and II of body posture dominated among the female

students, in the period of 2022, we recorded a significant ($p<0.05$) negative shift with a higher percentage representation in levels III (poor body posture) and IV (incorrect body posture) in the form of functional posture disorders. Female students with lower health-oriented physical fitness also had worse body posture. Younger female elementary school students in Žilina in 2022 (r=6.328) showed significantly worse results compared to female elementary school students in Žilina in 2012 (r=3.799).

A shift towards the worse has also occurred between levels I and II of body posture among younger female students, although these levels represent excellent (I) and good (II) body postures. As for the individual areas of body posture, in 2012 it was the area of head and neck position among younger female students, while in 2022, significant ($p<0.05$) changes were observed in the abdominal area, pelvic position, and frontal plane position, where changes were visible in the position of the shoulder blades and shoulders. According to further measurements, these findings were accompanied by headaches. In 2022, it was 25% of younger female students in Žilina elementary school who experienced headaches, while in 2012, it was only 8% of younger female students. This represents a threefold increase in headaches among younger female students in Žilina elementary school over 10 years.

Table 6 Overall assessment of body posture in younger female students (n=292)

Qualitative level of overall body posture of female students (Žilina 2012 and 2022)				
Female pupils/ Level of Body posture	Correct body posture (0-5 points)	Good body posture (6-10 points)	Bad body posture (11-15 points)	Incorrect body posture (16-20 points)
Female pupils 2012 (n= 150)	n=55 (36%)	n=63 (41%)	n=25 (17%)	n=9 (6%)
Female pupils 2022 (n=142)	n=28 (20%)	n=30 (21%)	n=64 (45%) *	n=20 (14%)
Difference (r) (n/%)	n=27 (16%)	n=33 (20%)	n=39 (28%)	n=11 (8%)
Chí-test (χ^2)	χ^2= 6. 977, ($p<0.05$)			

Legend: n - frequency, % - percentage frequency analysis, (source: own)

Discussion

Comparing our measurements with the results of research studies by several authors in Slovakia (Moravec et al., 1996; Krška, 2007), we observed a significant decrease in physical fitness and increase in body weight (obesity) in relation to their mutual relationships. We also found significant associations between adiposity indicators, overall body posture, physical fitness, and endurance abilities among female pupils in primary schools in Žilina.

Based on the comparison of somatic changes in 10 to 11-year-old female pupils from primary schools in Žilina in 2012 and 2022, we observed a slight increase in body height (1.98 cm; 1.33%) and an disproportionate increase in body weight (6.2 kg; 14.45%).

We consider the significant ($p<0.05$) decrease in physical fitness among female pupils from primary schools in the Žilina region as an important finding, which corresponds to the increase in body weight and significant decrease in endurance abilities. This finding is also confirmed by the fact that the decrease in physical fitness is significant ($p<0.05$) and dependent on the BMI index.

We also consider it a significant finding that as many as 103 (68.66%) female pupils from primary schools in Žilina in 2012 had an unsatisfactory level of physical fitness (Ruffier test - 21.85 index) and a high degree of obesity (BMI - 22.75 index). The same negative situation was observed among female pupils from primary schools in Žilina in 2022, where 95 (66.90%) had an unsatisfactory level of physical fitness (Ruffier test - 22.90 index) and a very high degree of obesity (BMI - 23.70 index). The mentioned findings are also presented in pubescent age pupils (Güngör, 2014; Chovanová & Majherová, 2016).

Unfortunately, only 21 (14.00%) female pupils from primary schools in Žilina in 2012 had a satisfactory level of physical fitness (Ruffier test - 11.4 index) and ideal body weight (BMI - 15.75 index). In 2022, only 15 (10.56%) female pupils from primary schools in Žilina had a satisfactory level of physical fitness (Ruffier test - 14.30 index) and ideal body weight (BMI - 16.50 index).

Incorrect body posture and posture disorders are common indicators of health problems and other internal organ systems in school-aged children. They can manifest in various forms, but most commonly, they lead to pain. We assume that increased body weight is one of the possible indicators of overall body posture, as well as insufficient health-oriented physical fitness. The lack of physical activity in the physical education regime of schoolchildren, both in school and out of school, is among the other most common reasons for these disorders and incorrect body posture. As a

preventive measure, we see the need to focus more on physically active schools, utilizing the potential of physical and sports education, as well as extracurricular activities focused on physical programs and activities after school (Bendíková, 2016; Vašková et al., 2022). It is important to note that early diagnosis and identification of incorrect body posture and disorders are prerequisites for the proper physical, movement, as well as psychological and social development of schoolchildren.

The school environment offers opportunities for primary prevention in relation to the postural health of schoolchildren, where the diversification of the content of physical and sports education, as well as the physical education teacher, play an important role in terms of the future lifestyle of schoolchildren (McKenzie & Lounsbery, 2014; Smoleňáková & Bendíková, 2017; Rus et al., 2019; Bendíková, 2020; Kryeziu et al., 2023).

Research limitations

The mentioned study was based on the methodology of Sport Science in obtaining qualitative and quantitative information about the monitored factors. The basis was pedagogical, multifactorial research that uses methods of physical education practice and not medical methods. The mentioned measurements and evaluations were carried out by experienced examiners with more than 25 years of experience in the given field. This means that our findings from the point of view of generalization need to be perceived in a wider context and are a suitable basis for the field of medicine and physiotherapy as factors that draw attention to the problem in the addressed area. Early diagnosis already at a given age can reveal possible health problems in the later period of pupils in the field of health (postural, cardiovascular and metabolic).

Conclusion

Comparing the changes that have occurred over ten years in the school population of female pupils from primary schools in Žilina, we have observed a significant increase in body weight, which we perceive as a very negative phenomenon. We also consider the significant decrease in physical fitness with a significant decrease in the endurance abilities of female pupils as negative. Unfortunately, only 14.00% of female pupils from primary schools in Žilina had a satisfactory level of physical fitness in 2012, and only 10.56% had a satisfactory level of physical fitness in 2022. There has also been a deterioration in overall body posture, with a higher percentage of representation in the third qualitative level. Based on our findings, we

consider the current state of body weight, body posture, physical fitness, and endurance abilities of female pupils from primary schools to be unsatisfactory and endangering their health. These facts need to be further addressed and preventive measures need to be taken.

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Conflicts of interest

The authors declare no conflict of interest.

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