



# The role of school medicine in the early detection and management of adolescent idiopathic scoliosis

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## Summary

**Objective** To analyze the trends in scoliosis screenings over 10 years (2010 vs. 2020). To assess the management of schoolchildren with a preliminary diagnosis of adolescent idiopathic scoliosis by school medicine specialists.

**Methods** Historical data were used for the year 2009/2010, and a cross-sectional study was conducted during the school year 2019/2020 on 18,216 pupils of 5th, 6th, and 8th elementary school grades. A forward bend test was used to detect clinical features of scoliosis and some positive findings were referred to orthopedists or physiatrists for further evaluation.

**Results** In the analyzed 10-year period abnormal forward bend test findings increased from 4.9 to 5.8% (by 18.4%;  $P < 0.001$ ). While its prevalence esca-

lated markedly in girls (from 5.8 to 8.3%;  $P < 0.001$ ), a modest but significant decrease, from 3.8 to 3.2% ( $P = 0.018$ ), was noted in boys. Most pupils had low to moderate curves, and its prevalence was some 6.5 times higher in girls ( $P < 0.001$ ). The forward bend test positive predictive value was 84.7%. Discrete forward bend test aberrations were managed by school medicine specialists only.

**Conclusion** While actively promoting scoliosis screening in children, we have shown that forward bend test is an acceptable tool for early adolescent idiopathic scoliosis detection in school medicine. In collaboration with other specialists and using additional diagnostic methods, school medicine specialists can ensure early detection and appropriate interventions, avoiding the potential harms of radiation exposure.

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## Introduction

Adolescent idiopathic scoliosis (AIS) is a medical condition defined by abnormal curvature of the spine with a curve of at least  $10^\circ$  (Cobb angle) on a standing spine radiograph with a vertebral rotation that appears at the age of 10–18 years [1]. In approximately 80% of cases, scoliosis is idiopathic, which means there is no known cause for this deformity, and the remaining 20% are secondary to some other underlying condition. It can progress due to many factors during a rapid period of growth [1]. The prevalence and severity of scoliosis are higher in girls than in boys [1, 2], and differ across countries, ranging from 0.47% to 12%, with the leading estimate between 2% and 3% [1, 2]. School screening for scoliosis has been implemented worldwide for a long time but its value has often been questioned. For instance, according to the

United States Preventive Services Task Force (USPSTF) in 1996, there was insufficient evidence to recommend for or against routine screening of asymptomatic adolescents for AIS [3]. In 2004 USPSTF implied that conservative treatment, especially brace wear, may be potentially harmful and argued against preventive screening for AIS [4]. Even though the Bracing in Adolescent Idiopathic Scoliosis Trial (BrAIST) reported the effectiveness of early management by bracing [5], the latest USPSTF recommendation, issued in 2018, stated that there is not sufficient evidence in favor of or against screening for AIS in children and adolescents [6]. Currently, preventive screening is not recommended in the United Kingdom, Canada, Australia, and Scandinavian countries, except Sweden [7]. In the USA there is no national policy in this respect, and depending on the state, school AIS screening may be mandatory or optional [7]. In Europe, it is endorsed in 6 countries: Belgium, Malta, Cyprus, Croatia, Slovenia, and Sweden [8].

Some of the benefits of an effective screening program are early detection, less invasive treatment or intervention [9]. In the case of AIS, the absolute goals for children are to avoid fusion surgery, improve esthetics and quality of life [1]. Screening allows early detection, while conservative treatment, especially bracing, can stop curve progression or possibly even reduce it [5]. According to Weinstein et al. [10], curves held at 30° at skeletal maturity rarely get worse. Therefore, our commitment should be prevention of severe scoliosis.

The Republic of Croatia has a mandatory public healthcare insurance system with a significant emphasis on preventive medicine. It has a unique medical specialty unlike other countries in the European Union, called the school and adolescent medicine specialty, which consists of 4 years postgraduate training. Many school medicine specialists (school doctors) have additional training required for counseling (cognitive behavioral therapy, mindfulness, etc.) They provide preventive and specific healthcare for schoolchildren and university students under the jurisdiction of public health. Each school and university has an appointed school medicine doctor, thus providing universal coverage. The activities of school doctors include mandatory immunization, general medical and other preventive examinations, health education and promotion, counseling and care of children with special needs, epidemiological and environmental activities, cooperation with teachers and school experts in the evaluation of children before enrolment or during school education if they have learning disabilities.

In Croatia, as specified by the national plan and program of healthcare measures, scoliosis screening is a part of the planned health measures along with other screening (e.g. anemia, proteinuria, blood pressure, risk behavior). The prescribed screening method is a forward bend test (FBT), and it is performed in the 6th grade, and also in every systematic examination

(examination prior to enrolment in school, 5th and 8th grades of primary school, 1st grade of secondary school, 1st university year). Scoliosis and postural abnormalities most often occur during the growth spurt [1]. Our systematic examinations and scoliosis-specific screening coincide with the rapid growth spurt in puberty, but also provide continuous monitoring and case-finding. Specific scoliosis screening starts with taking anthropometric data and assessing the pubertal stage. Observation of posture changes characterized by scoliosis like asymmetry in shoulder level, waistline and hips and leg length discrepancy is noted. It is followed by the time-honored Adams forward bend test, described by Dr. William Adams in 1865 [11] for detection of scoliosis, including the rotation patterns and rib hump. The discrepancy between the FBT positivity and definitive diagnosis of AIS was described by 2016 International Scientific Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT) guidelines [2]: therefore, any major aberration in FBT (structural or postural asymmetry) is referred to an orthopedist or physiatrist for further evaluation, to confirm or exclude the diagnosis of AIS. We follow a two-step scoliosis screening procedure described by Leone et al., which provides reasonable sensitivity and specificity while reducing costs and radiation [1]. In the first step, the school doctor performs a clinical examination, and in the second step uncertain cases are referred to an orthopedist. The screening directly performed by orthopedists would result in a higher number of X-ray examinations while using a two-step procedure reduces radiation exposure and costs [12]. Referral as a second step in the management of suspected AIS is important because besides FBT school doctors do not use more objective measurements, like a scoliometer, topography, or radiography. Since they do not order X-ray imaging they lack more objective data. According to SOSORT 2016 guidelines [1], it is important to use one of the clinical cut-off points such as the angle of trunk rotation (scoliometry), before ordering radiographic imaging. Also, Croatian children referred to physiatrists are entitled to corrective exercise treatment which cannot be provided in a school medicine setting. The entire screening pathway, from identification, referral, further investigation, treatment and rehabilitation is covered by the compulsory health insurance.

The morbidities of schoolchildren diagnosed by school doctors during systematic examinations for all grades are reported annually to the Croatian National Institute of Public Health by regional Institutes of Public Health. For the school year 2009/2010, they were included as a part of the Croatian Health Service Yearbook 2010 [13], but the data presented a total number of children diagnosed with presumed scoliosis in primary school, without distinguishing whether it was juvenile or adolescent scoliosis. No studies have reported the exact prevalence of AIS in Croatia. In our report, we aimed to determine the

prevalence of abnormal FBT findings (presumed AIS) among 5th, 6th and 8th grade schoolchildren and also to present the work and role of school doctors in the early detection of AIS.

## Material and methods

### Study design

This cross-sectional study was conducted in Croatia by analyzing the data from the school year 2019/2020. The Ethics Committee of the Institute of Public Health approved this research (Class: 500-01/19-01/7; Registry number: 2181-103-01-19-1). Informed consent and assent were obtained from parents and children.

The obtained data for the school year 2019/2020 were noted in a survey form designed for this study and comprised information related to those medical records of pupils (age, gender, class, family history of scoliosis, physical activity, anthropometric data, clinical signs indicating scoliosis, particularly FBT), respective measures undertaken by school doctors, orthopedist or physiatrist referral results (i.e. diagnosis verification with the gold standard, Cobb's angle quantification or raster stereography, scoliometry).

For the retrospective analysis (the school year 2009/2010), part of the data used for comparison of positive FBT prevalence was openly available and presented in the Croatian Health Service Yearbook 2010. Another part of the data was acquired from the annual reports of the regional Institutes of Public Health.

### Patients

Retrospective data for 24,354 pupils in the school year 2009/2010 were obtained from participating counties, available for the 5th and 8th grades (12,695 of the 5th and 11,659 of the 8th grade) only as reports of the scoliosis-specific examination in the 6th grade were missing.

Inclusion criteria for the prospective part of this study were: 5th, 6th and 8th grades elementary school children, aged around 11, 12, and 14 years, respectively, in 4 Croatian counties (Split-Dalmatia, Primorje-Gorski Kotar, Varaždin, and Osijek-Baranja) examined by school doctors, with properly completed study-specific survey form and informed consent. Exclusion criteria were incomplete data in the survey form, decline of consent/assent, or scoliosis due to other conditions (congenital, inflammatory, traumatic, neuromuscular, etc.). A total of 18,216 pupils were included, as shown on the flowchart (Fig. 1).

### Examination procedure

Examinations were conducted in doctor's offices, not in schools, to minimize the psychological impact of scoliosis screening on children. After the school nurse

measured height, and weight, and calculated the body mass index, the physical examination was conducted by the school doctor. The clinical features of scoliosis were assessed with the examinee in a standing position from the front, side, and behind. Afterwards, the FBT was performed: the examinee was asked to bend forward at the waist, allowing the arms to hang freely with the palms opposed in a relaxed manner, while the examiner estimated back symmetry from behind and beside, and checked for a rib hump [14]. This test has a sensitivity of 84.3% and specificity of 93.4% [15].

For this study, AIS diagnosis was stratified into three levels into:

1. Presumed (positive FBT)
2. Very likely (confirmed by raster stereography, scoliometry)
3. Definitive (verified by X-ray imaging; Cobb's angle  $> 10^\circ$ )

### Statistics

All statistical analyses were performed using the IBM SPSS 20.0 package (IBM Corp, Armonk, NY, USA). Descriptive statistics for proportions are presented as percentages. Nonparametric tests were used to evaluate differences/relationships between the observed variables ( $\chi^2$ -test, Mann-Whitney *U* test, Kruskal-Wallis test, Spearman's correlation, as appropriate). *P*-values  $< 0.05$  were considered statistically significant.

## Results

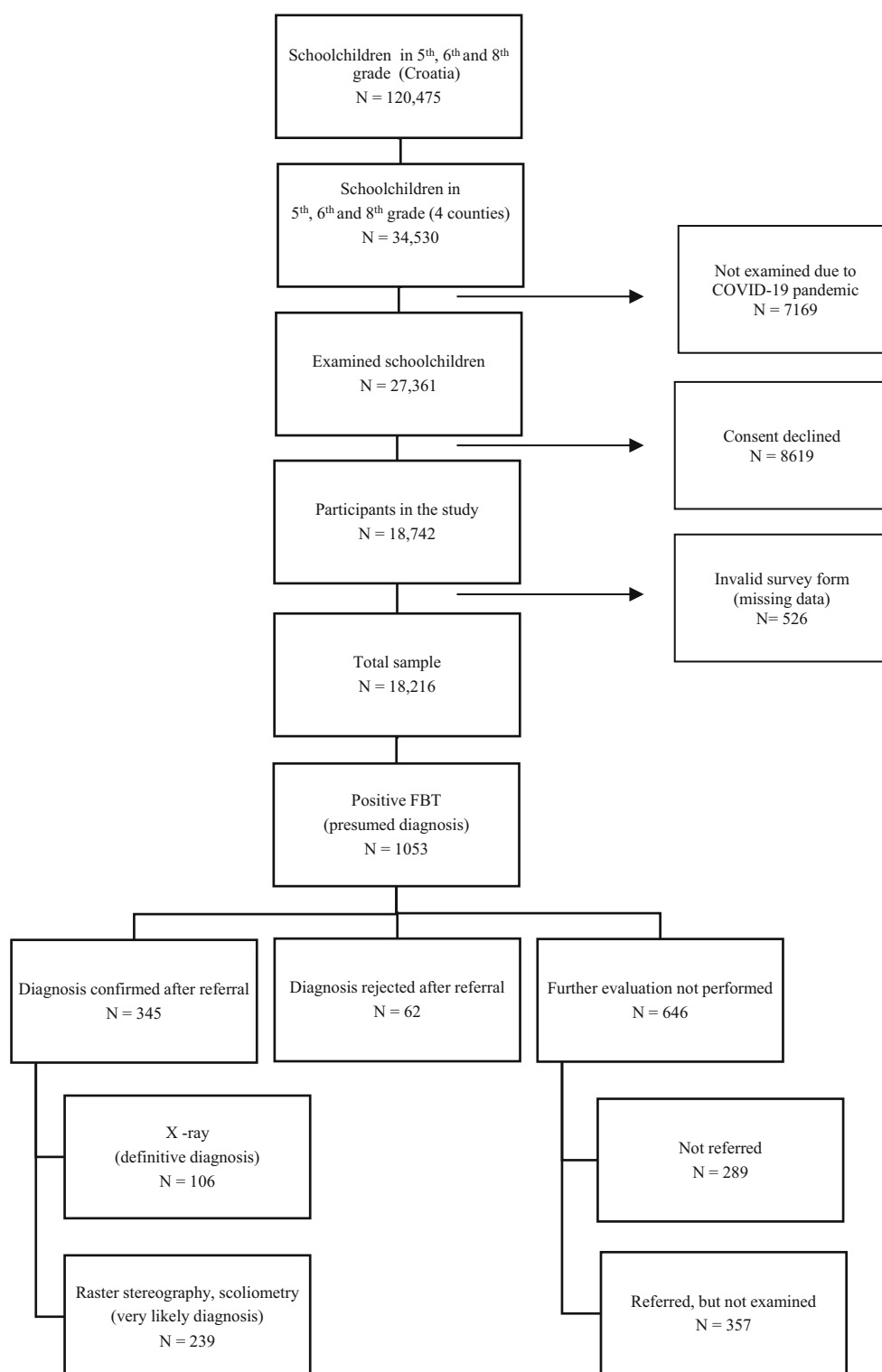
For the school year 2009/2010 the data were available for 24,354 pupils. For the school year 2019/2020, out of 27,361 examined schoolchildren, 18,216 were included in the study (66.6%). The prevalence of abnormal FBT findings increased between the years 2009/2010 and 2019/2020 from 4.9% (1186/24,354) to 5.8% (1053/18,216);  $\chi^2 = 17.349$ , *df* 1,  $P < 0.001$  (Table 1). A higher prevalence among girls was observed in both periods: it increased in girls from 5.8% to 8.3% ( $\chi^2 = 55.503$ , *df* 1,  $P < 0.001$ ), while in boys it decreased from 3.8% to 3.2% ( $\chi^2 = 5.538$ , *df* 1,  $P = 0.018$ ).

A family history of scoliosis was obtained and noted for 16,017 (87.9%) of the examinees. FBT positive individuals had positive family history of scoliosis more often than those without (13.2%, 151/1141 vs. 4.9%, 730/14,876;  $\chi^2 = 141.358$ , *df* 1;  $P < 0.001$ ).

Since the survey form was specifically designed for the school year 2019/2020, and provided necessary information from medical records, additional statistical analysis was done for these pupils. In this subgroup, a positive FBT was found in 8.3% (758/9085) of the girls and 3.2% (295/9131) of the boys (Table 1, lower part). The ratio of girls to boys with suspected scoliosis was 2.5:1, and this sex difference was statistically significant ( $\chi^2 = 218.560$ , *df* 1;  $P < 0.001$ ).

Significant correlations were found between presumed AIS diagnosis (+ FBT), clinical signs of scol-

**Fig. 1** Flowchart of the prospective, cross-sectional part of the study



iosis, and gender (Table 2). A negative association was established between body mass index (BMI) and positive FBT. Similar findings were noted when the confirmed diagnosis (very likely + definitive diagnosis) was compared to these variables. A strong positive correlation was established between presumed and confirmed AIS diagnosis (Spearman's rank correlation

coefficient [ $r_s$ ] = 0.85,  $P < 0.01$ ). A weak but significant positive correlation with confirmed AIS diagnosis was established for height ( $r_s = 0.23$ ,  $P < 0.01$ ), school grade ( $r_s = 0.31$ ,  $P < 0.01$ ) and gender ( $r_s = 0.17$ ,  $P < 0.01$ ).

Pupils with discrete aberrations in the FBT test ( $n = 289$ ) remained under school doctor care without additional referral to other specialists, were advised

**Table 1** Prevalence of a presumed adolescent idiopathic scoliosis (positive forward bend test)

Grade	Positive FBT		Negative FBT		Total	
	N	M/F	N	M/F	N	M/F
<i>2009/2010</i>						
5th	392	144/248	12,303	6335/5968	12,695	6479/6216
8th	794	294/500	10,865	4621/6244	11,659	4915/6744
Total	1186	438/748	23,168	10,956/12,212	24,354	11,394/12,960
<i>2019/2020</i>						
5th	216	52/164	6132	3150/2982	6348	3202/3146
6th	205	51/154	3956	2017/1939	4161	2068/2093
8th	632	192/440	7075	3669/3406	7707	3861/3846
Total	1053	295/758	17,163	8836/8327	18,216	9131/9085

*FBT* forward bend test, *AIS* adolescent idiopathic scoliosis, *M* male, *F* female, *N* number of pupils

**Table 2** Correlations between variables

	Grade	Gender	Height	Weight	BMI	Shoulder asymmetry	Shoulder blade asymmetry	Rib hump	Waistline asymmetry	Hips asymmetry	Legs asymmetry	Presumed AIS	Confirmed AIS
Grade	1.000	–	–	–	–	–	–	–	–	–	–	–	–
Gender	0.003	1.000	–	–	–	–	–	–	–	–	–	–	–
Height	0.694**	–0.079**	1.000	–	–	–	–	–	–	–	–	–	–
Weight	0.522**	–0.059**	0.728**	1.000	–	–	–	–	–	–	–	–	–
BMI	0.245**	–0.015*	0.315**	0.863**	1.000	–	–	–	–	–	–	–	–
Shoulder asymmetry	0.042**	0.063**	0.060**	0.012	–0.026**	1.000	–	–	–	–	–	–	–
Shoulder blade asymmetry	0.038**	0.059**	0.069**	–0.015*	–0.068**	0.516**	1.000	–	–	–	–	–	–
Rib hump	0.069**	0.081**	0.061**	0.012	–0.029**	0.211**	0.229**	1.000	–	–	–	–	–
Waistline asymmetry	0.028**	0.090**	0.053**	–0.007	–0.046**	0.320**	0.399**	0.288**	1.000	–	–	–	–
Hips asymmetry	0.026**	0.041**	0.037**	0.000	–0.026**	0.174**	0.184**	0.173**	0.330**	1.000	–	–	–
Legs asymmetry	0.016*	0.025**	0.000	–0.001	0.001	0.163**	0.082**	0.076**	0.115**	0.177**	1.000	–	–
Presumed AIS	0.091**	0.110**	0.089**	0.015*	–0.042**	0.270**	0.317**	0.655**	0.407**	0.275**	0.119**	1.000	–
Confirmed AIS	0.310**	0.176**	0.239**	0.100**	–0.039	0.276**	0.274**	0.635**	0.413**	0.263**	0.155**	0.854**	1.000

*BMI* body mass index, *AIS* adolescent idiopathic scoliosis  
 \*\*Correlation is significant at the 0.01 level (2-tailed)  
 \*Correlation is significant at the 0.05 level (2-tailed)

to engage in sports activities, and received handouts with basic corrective exercise protocols.

Out of 764 referred children, the presumed diagnosis of scoliosis was rejected by the orthopedist or physiatrist in 5.9% ( $n=62$ ) of cases. Contrary to school doctor recommendations, 33.9% ( $n=357$ ) did not obtain a second opinion. The diagnosis of AIS was initially confirmed by other specialists in 345 pupils (250 female, 95 male) with the ratio of girls to boys 2.6:1 ( $\chi^2=0.252$ ,  $df\ 1$ ,  $P=0.359$ ). The cumulative predictive value of FBT in these schoolchildren was 84.7% (i.e. 345/407).

Spine radiography was done in 106 (10.1%) out of 1053 FBT positives. Additionally, in 239 (22.7%) pupils

scoliosis was confirmed as very likely by other methods, like raster stereography or scoliometry.

Pupils with X-rays were classified according to the Cobb degree [2], as shown in Table 3: A Cobb angle above  $10^\circ$  was registered in 90 of them (84.9%); the most prevalent deformity was between  $10^\circ$  and  $20^\circ$  ( $N=45$ ; 42.5% of them), followed by 28.3% of those with  $21\text{--}35^\circ$ , while only 14.1% had advanced levels of scoliosis (i.e.  $>36^\circ$ ). The Cobb angle  $<10^\circ$  was noted in 16 cases. They had previously confirmed AIS with Cobb angle  $>10^\circ$  and underwent corrective exercise treatment, and 4 pupils in addition wore braces (“No AIS” column in Table 3).

**Table 3** Definitive AIS classification according to Cobb angle measurement

Grade	Curvature intensity (Cobb degree) ( <i>N</i> = 106)						
	No AIS < 10°	Low 10–20°	Moderate 21–35°	Moderate to severe 36–40°	Severe 41–50°	Severe to very severe 51–55°	Very severe > 56°
	M/F	M/F	M/F	M/F	M/F	M/F	M/F
5th	0/5	1/2	0/1	0/0	0/1	0/0	0/0
6th	0/2	2/7	0/8	0/1	0/0	0/0	0/1
8th	3/7	3/30	3/18	0/3	0/4	1/1	2/1
Total	3/14	6/39	3/27	0/4	0/5	1/1	2/2

*M* male, *F* female, *AIS* adolescent idiopathic scoliosis, *N* number of pupils

The difference between boys and girls after radiographic assessment was again statistically significant; AIS was more prevalent among girls ( $\chi^2 = 14.303$ , *df* 1,  $P < 0.001$ ). Nevertheless, the difference by gender regarding the size of curvature was not significant (Mann-Whitney *U* test = 610.500,  $P = 0.514$ ), and there were no notable differences in curvature size in different school grades (Kruskal-Wallis test = 3.963,  $P = 0.138$ ).

## Discussion

Schoolchildren in Croatia undergo mandatory systematic examinations and specific screenings for scoliosis. Yet, the prevalence rate of AIS is unknown because school doctors establish their working diagnosis of scoliosis upon a positive FBT. Therefore, we wanted to establish what happens after schoolchildren get a preliminary diagnosis of AIS. As mentioned before, in our two-step screening procedure, uncertain and severe cases are referred for further evaluation by orthopedists and/or physiatrists. The main reason is that school medicine is purely preventative, not curative and cannot directly provide corrective treatment. Moreover, since FBT is the only screening tool, referral to other specialists (more sophisticated screening methods) is imperative to prevent unnecessary radiation (e.g. suspicion of false positive or false negative findings).

The prevalence rate of positive FBT (presumed diagnosis of AIS) in our study of 5.8% is comparable to its global estimates, ranging from 0.47–12% [1, 2]. Our sample was robustly representative, amounting to 15.1% of the surveyed population in Croatia, resulting in a strong, positive correlation with the confirmatory diagnosis of AIS by other consultants ( $r_s = 0.85$ ,  $P < 0.01$ ). Nevertheless, FBT is not considered a reliable AIS diagnostic tool [15]. Our data show that children with discrete FBT aberrations are usually not referred for further targeted evaluation, but managed by a school medicine doctor (explanation, education, written handouts) with re-evaluation after several months, following basic corrective exercises and recommendations for active participation in sports commensurate to the age and degree of scoliosis. Even children with inappropriate posture

are counseled in terms of prevention. Patients with discrete aberrations are observed without treatment [1, 6], and further steps are based upon regression or progression of the condition. Through our active observation and counseling of children and parents we strive to increase compliance to further investigation or treatment. Since the management of children with a preliminary diagnosis of AIS does not mandate additional diagnostic evaluation, the exact prevalence of AIS in Croatia remains unclear.

Over 10 years, the prevalence of positive FBT increased from 4.9% to 5.8%, i.e. by 18.5% (0.9% in absolute terms). The relative increase was obvious in girls (from 5.8% to 8.3%, i.e. by 43.1%) while even negative in boys (a decrease from 3.8% to 3.2%, i.e. by 18.8%). The pathogenesis of AIS is unknown. It is generally held that its cause is multifactorial, resulting from the interplay of multiple genes and environmental factors. The identification of soft tissue anomalies and genes that play role in muscle development suggests that AIS initiation is modifiable by exercise, stretching, bracing, etc. [16]. Since the majority of adolescents, in particular girls, do not meet the current guidelines on physical activity [17], we presume that lifestyle trends (increased screen time, physical inactivity, and sedentary behavior) are the leading culprits. The association between low physical activity and scoliosis was described in a recent study [18], in which the FBT was used to assess scoliosis. The observed gender difference may be due to the fact that boys are more involved in sports and physical activity while girls prefer a more sedentary lifestyle, the trend noted in the latest Croatian Health Behaviour in School-aged Children survey in 2017/2018 [19].

About one third of our participants did not consult an orthopedist or a physiatrist contrary to our advice. Since the school year 2019/2020 was marked by the coronavirus disease 2019 (COVID-19) pandemic, this disaster definitively contributed to this failure. Other authors also reported on the impact of COVID-19 on AIS referrals, showing a drop rate from 76% to 55% in the first 7 months of the pandemic [20]. According to Adobor et al. [21], in the absence of scoliosis screening parents and other laypeople detect only 71% of AIS cases already suitable for brace treatment. In Canada, where school scoliosis screening is also discontinued,

it was shown that scoliosis curves perceived by parents were 7.1° larger than those identified by doctors [22]. Thomas et al. reported a 48% drop in referrals after school screening discontinuation, while the scoliosis severity and bracing rates increased [23]. It seems that in discrete cases of scoliosis parents do not perceive the need for further evaluation because the condition is mostly painless.

Our presumptive diagnosis was verified as a definitive by radiography in only 10.1% ( $n=106$ ), and as very likely by other methods in 22.7% of the cases. Although radiography is the gold standard in AIS diagnosis, it was seldom used for several possible reasons. First, it is not mandatory to take a baseline X-ray of a new patient to evaluate scoliosis if other clinical observations are normal [24]. The fact that most of our participants with a definitive diagnosis had low to mild curves favors this statement. Second, one may wonder whether the imaging was additionally postponed due to the fear of future malignancy following cumulative radiation exposure. Presumably, yes. There is a widespread agreement to avoid unnecessary and repeated use of X-rays in children. The SOSORT consensus states that when used appropriately, nonradiographic modalities (physical examination, scoliometer reading, and surface topography) should be used first in the evaluation of progression [24]. Contrary to Oakley et al. [25], who concluded that the cumulative dose of 25 mGy is far below the dose threshold for radiogenic cancer, a recent review on low radiation [26] has shown that neither the medical community nor the public at large is aware enough of the cumulative exposure risks; the current AIS gold diagnostic standard slightly but irrevocably increases the risk of cancer. Since low/zero radiation imaging techniques are nowadays available (the microdose EOS, raster stereography, 3D ultrasound scolioscan), a question arises whether this is the path to follow to reduce potential harm [26]?

A similar female to male ratio was observed in our presumed and confirmed AIS diagnoses (2.5:1 and 2.6:1), comparable to the overall prevalence ratio presented in a review by Konieczny et al. [2]; however, in those assessed with spine radiography (definitive diagnosis), our female to male ratio was considerably higher, even among low and moderate deformities. For Cobb angle of 10–20° it was 6.5:1 vs. 1.4:1, in 21–40° angle it was 10.3:1 vs. 2.8–5.4:1, and in severe, >40° angle, it was 4:1 vs. 7.2:1.

Compared with healthy pupils, our AIS patients were taller and had lower BMI. Following our results, a prospective study on the relation of body composition and scoliosis showed this negative association [27], and similar findings were reported not only for BMI and scoliosis [28–30] but for height and weight as well [30, 31].

This report had several limitations. It is plagued with all the shortcomings of observational or cross-sectional trials. The retrospective part could use only

the available data from annual medical reports. Due to several objective impediments, the drop-out rate was very high; out of possible 34,530 examinees included were only 18,216 (52.7%), 1053 of which had positive FBT; of those 1053 only 764 (72.6%) were referred for confirmatory assessment, out of which just 407 (38.6% of 1053, 53.8% of 764) were indeed evaluated, and mere 106 of them (i.e. 10.1% out of 1053 FBT positives) underwent imaging evaluation with the Cobb angle measurement. We tried to establish the AIS prevalence based on FBT aberrations, but can only contemplate its exact prevalence, since not all FBT positives were referred for definitive assessment, and FBT negatives were excluded from such an intervention for obvious ethical and logistic reasons.

Summing up, the Adams forward bend test is currently the main screening method for scoliosis in Croatia. Our results showed a strong, positive correlation between the presumptive diagnosis of AIS based on FBT and confirmative verification and FBT's positive predictive value of 84.7%. The test is simple to perform assuming that the examiner is experienced enough [2, 13], and school doctors are trained to adequately perform this test during their 4-year specialty program. Of course, with a sensitivity of 84.3% and specificity of 93.4%, FBT is not an absolutely accurate test for early detection of scoliosis [13], and the use of a scoliometer may slightly improve the screening reliability [2].

## Conclusion

Discrete scoliotic aberrations can be controlled and managed at the primary care level of school medicine, decreasing the number of unnecessary referrals. Schoolchildren are monitored by school doctors during the entire course of their education; even those who failed to report to the orthopedist will be re-evaluated in follow-up assessments and scoliosis progression reverted. Our screening pathway covers almost all stages of AIS management, but we lack a register of AIS patients. The test results are recorded as a part of a routine care, disabling an effective recall system and monitoring of the program. In practice, each school team (medical doctor/nurse) schedules control examinations either through school or parents. This consistency in follow-up is particularly important considering the rise of positive FBT prevalence over 10 years. Since most of our pupils had low to moderate scoliosis, FBT seems to be a sufficient tool for early detection of AIS, and in alliance with other specialists, along with the use of more sophisticated screening methods, we can minimize the potential harm of unnecessary X-rays in screening and increase the accuracy of AIS detection.

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## Declarations

**Conflict of interest** J. Glavaš, M. Rumboldt, Ž. Karin, R. Matković, S. Kresina, N. Dragaš-Zubalj, and J. Aljinović declare that they have no competing interests.

**Ethical standards** All procedures performed in studies involving human participants or on human tissue were in accordance with the ethical standards of the institutional and/or national research committee and with the 1975 Helsinki declaration and its later amendments or comparable ethical standards. This cross-sectional study was conducted in Croatia by analyzing the data from the school year 2019/2020. The Ethics Committee of the Institute of Public Health approved this research (Class: 500-01/19-01/7; Registry number: 2181-103-01-19-1). Informed consent and assent were obtained from parents and children.

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