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Screening recommendations for early detection of idiopathic scoliosis – consensus by a multidisciplinary Task Force at Committee for Rehabilitation, Physical Culture and Social Integration of Polish Academy of Sciences

Wczesne wykrywanie skoliozy idiopatycznej – interdyscyplinarne rekomendacje Zespołu Komitetu Rehabilitacji, Kultury Fizycznej i Integracji Społecznej Polskiej Akademii Nauk

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Abstract

Introduction and objective: Idiopathic scoliosis is a three-dimensional deformity of the spine with an unknown aetiology. Untreated idiopathic scoliosis may lead to trunk deformities that compromise body aesthetics, reduce chest wall mobility, and decrease physical capacity. Therefore, early detection of idiopathic scoliosis is crucial as it can minimise the risk of idiopathic scoliosis progression, and can eliminate the need for surgical treatment. In Poland, there is no standardised screening system for early detection of idiopathic scoliosis. The aim of the study was to develop the recommendations for screening of idiopathic scoliosis. **Materials and methods:** Fifteen experts, including physiotherapists, physicians and physical education teachers, created a Team of Experts in order to develop recommendations. Team members were divided into three groups, each tasked with addressing the following issues: "How to screen?", "Who and when to screen?", and "Who should screen?". The recommendations were evaluated using the Delphi technique and the nominal group technique in two areas: agreement and the strength of recommendations. **Results:** A total of 16 recommendations for early detection of idiopathic scoliosis were developed. **Conclusions:** 1. Screening should use reliable, sensitive, and specific diagnostic tools and methods to minimise the risk of under- and overdiagnosis. Measurements of the angle of trunk rotation performed using a scoliometer meet the above criteria. 2. A recommended cut-off for angle of trunk rotation for early detection of idiopathic scoliosis should be ≥7°.

Keywords: recommendations, early detection, idiopathic scoliosis, scoliometer

Streszczenie

Wprowadzenie i cel: Skolioza idiopatyczna to trójpłaszczyznowa deformacja kręgosłupa o nieustalonej etiologii. Nieleczona może prowadzić do deformacji tułowia i wpływać negatywnie na estetykę ciała. Skolioza idiopatyczna przekraczająca tzw. poziom krytyczny (30–50°) może skutkować obniżeniem jakości życia, powodując dolegliwości bólowe, ograniczenia funkcjonalne i widoczną niepełnosprawność. Celem pracy było przygotowanie rekomendacji dotyczących prowadzenia badania przesiewowego mającego na celu wczesne wykrycie skoliozy idiopatycznej. **Materiał i metody:** Piętnastu ekspertów, w tym lekarze, fizjoterapeuci i nauczyciele wychowania fizycznego, weszło w skład Zespołu Ekspertów, którego zadaniem było opracowanie rekomendacji. Członkowie Zespołu reprezentowali 12 ośrodków, niezależnych od siebie organizacyjnie i finansowo, wśród których były zarówno placówki realizujące świadczenia publicznego systemu ochrony zdrowia, jak i świadczące usługi komercyjne. Przygotowane rekomendacje opracowano w trzech obszarach: „Jak prowadzić badanie przesiewowe?", „Kto i kiedy powinien być objęty badaniem przesiewowym?" oraz „Kto powinien prowadzić badanie przesiewowe?". Do opracowania rekomendacji wykorzystano kombinację metody Delphi i techniki grupy nominalnej (*nominal group technique*). **Wyniki:** Ostatecznie zaproponowano 16 rekomendacji w zakresie prowadzenia badania przesiewowego mającego na celu wczesne wykrycie skoliozy idiopatycznej. **Wnioski:** 1. Badanie przesiewowe mające na celu wczesne wykrycie skoliozy idiopatycznej powinno być prowadzone z wykorzystaniem wiarygodnych, zweryfikowanych pod względem czułości i swoistości narzędzi i metod diagnostycznych, aby zminimalizować ryzyko wyników fałszywie ujemnych i fałszywie dodatnich. Kryteria te spełnia ocena kąta rotacji tułowia wykonana za pomocą skoliometru. 2. Rekomendowanym punktem odcięcia w badaniach przesiewowych jest kąt rotacji tułowia wynoszący ≥7°.

Słowa kluczowe: wytyczne, badanie przesiewowe, skolioza idiopatyczna, skoliometr

INTRODUCTION

Idiopathic scoliosis (IS) is a three-dimensional spinal deformity of unknown aetiology[1], which is diagnosed when Cobb angle on an anteroposterior x-ray of the spine is ≥10°[2,3]. Although X-ray examination is the gold standard in IS diagnosis, its use should be limited due to its invasive nature[3].

If left untreated, IS may lead to significant trunk deformities, compromising body aesthetics. Scoliosis with curves above the so-called critical level (30–50°)[4] may be associated with reduced quality of life due to pain, functional limitations and evident disability[5,6].

Furthermore, IS patients present with reduced vital capacity, limited chest mobility and respiratory rhythm disturbances. Reduced vital capacity and increased forced expiratory volume in 1 second (FEV_1) are positively correlated with the Cobb angle[7,8].

The importance of early detection of IS has been emphasised in order to prevent these consequences[9]. As pointed out by the Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT), screening should aim at early detection of IS, which will allow for monitoring or treatment initiation in the child. This may reduce the risk of IS progression to a level requiring surgical treatment leading to permanent spinal stiffness[3,10]. However, SOSORT only recommends cut-off points enabling a reliable assessment of dorsal asymmetry[9,11], with no reference to a detailed description of how to conduct the screening, who should be screened or who should perform the screening.

There is currently no universal, standardized screening system for the early detection of IS in Poland. It is assumed that IS should be diagnosed at physical development and body posture screening during paediatric health check-ups. The lack of standardised principles for conducting such screening prompts the use of non-specific diagnostic tools and techniques, which may lead to misdiagnosis[12].

A false negative screening test may result in IS progression, the need for bracing, and, in the case of severe deformities, surgery. A false positive screening result, i.e. diagnosis of IS in a person without spinal deformity, causes unnecessary stress for the child/parents and unneeded treatment, which burdens the healthcare system (medical and physiotherapy consultations, diagnostic imaging)[12,13].

Therefore, the Committee for Rehabilitation, Physical Culture and Social Integration of the Polish Academy of Sciences (referred to as the Committee later in the paper) appointed the Task Force for the Diagnosis and Conservative Treatment of Idiopathic Scoliosis (referred to as the Team later in the paper), assigned to develop recommendations on the standards for conducting screening for early detection of IS.

MATERIALS AND METHODS

Methods

The study used the Delphi technique in combination with the nominal group technique (NGT)[14–17].

The Team

The Committee responsible for the development of recommendations consisted of 38 members representing various medical and scientific disciplines in the field of rehabilitation, orthopaedics, physiotherapy, physiology, sports medicine, physical education, psychology and social integration. After appointing the Team by the Committee, its chairman was selected, who was a member of the Committee,

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a physiotherapist with 20 years of clinical and scientific experience in the diagnosis and treatment of children and adolescents with spinal deformities, including IS. The remaining members of the Team were selected based on the following criteria: 1) a physician with at least 10 years of clinical or scientific experience in the diagnosis and treatment of children and adolescents with IS; 2) a physiotherapist with at least 10 years of clinical or scientific experience in the diagnosis and treatment of children and adolescents with IS; 3) a physical education teacher specialised in corrective and compensatory gymnastics with at least 10 years of experience in conducting classes with children and adolescents with postural defects.

The principle of diversification in terms of medical profession, clinical and scientific experience and place of work was adopted for nominating candidates for the Team[17]. Ultimately, the Team was composed of 15 experts, including 9 physiotherapists, 7 physicians (3 orthopaedists, 2 physicians specializing in medical rehabilitation and 2 paediatricians) and 2 physical education teachers (the number does not add up to 15, because some of the Team members represented more than one profession or one medical specialisation).

The Team members were employed in 12 organizationally and financially independent centres, including both public health care system facilities and commercial services.

The Team also included an epidemiologist/statistician, who was responsible for independent data collection and analysis of the collected data, anonymous for the other members of the Team. For this purpose, an appropriate form was developed, which was sent via e-mail to each Team member. None of the other Team members had access to the submitted responses.

All Team members participated in the work as volunteers and did not receive any financial compensation[18].

Data collection

During the first meeting of the Team, three dimensions were identified for which recommendations would be developed: "How to screen?", "Who and when to screen?", and "Who should screen?".

This was followed by:

- an analysis of the guidelines proposed by international scientific societies and organisations with expertise in the field of IS: SOSORT, Scoliosis Research Society, International Research Society of Spinal Deformities, North American Spine Society, and US Preventive Task Force[3,19–21];
- an analysis of literature, involving the search through the Web of Science and Scopus databases using the following keywords: "idiopathic scoliosis", "screening", "diagnosis", "treatment";
- an analysis of legal regulations underlying the organisation of health care in Poland.

Based on these analyses, preliminary proposals for recommendations were developed and evaluated using the Delphi and NGT approaches[14–16,22,23].

The proposed recommendations were assessed for agreement and strength. In order to assess agreement, each recommendation was assigned one of five options: 1) "I agree", 2) "I rather agree", 3) "I have no opinion", 4) "I rather disagree", 5) "I disagree". It was assumed that consensus was achieved with at least 80% of "I agree" responses.

Additionally, each Team member assessed the strength of a given recommendation on a 4-point scale, where:

A. recommendation is very important and must be strictly followed at screening;
B. recommendation is important, but does not necessarily have to be followed in every situation;
C. recommendation is less important and may be used during screening at the investigator's discretion;
D. recommendation has a low level of significance[3].

It was assumed that the final recommendations would include those that were identified as A by at least 80% of votes[3].

If a proposed recommendation did not meet the required level of agreement and strength, it was discussed and either rejected or changed. In the latter case, it was re-evaluated in another Delphi round.

RESULTS

A total of 36 recommendations were initially proposed (Tab. 1). As a result of the discussion held during the Team meeting, the contents of four proposals (2, 3, 6, 10) for "How to screen?" were modified. As for "Who and when to screen?" and "Who should screen?", no modifications had been introduced in the recommendations before the first Delphi round.

The first Delphi round

After the first Delphi round, the number of recommendations that achieved a minimum agreement level of 80% and strength level A of 80% was 11 for "How to screen?" and 4 for "Who and when to screen?". As for "Who should screen?", none of the recommendations achieved the required level of agreement and strength.

The final number and content of recommendations are the outcome of 4 Delphi rounds and expert discussions on the outcomes of the individual stages of this procedure.

It was found upon completion of the fourth Delphi round that all proposed recommendations achieved the required level of agreement. In terms of strength, 13 of the proposed 16 recommendations achieved an appropriate level (>80%). Based on the results of the fourth round, it was decided that a consensus had been reached to formulate the final recommendations (Tab. 2).

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	How to screen?
1	For the early detection of IS, it is recommended to evaluate trunk asymmetry using the Adam's forward bend test (ATR measurement).
2	*Recommended starting position of the subject: standing with feet parallel, in line, hip width apart; knee joints straightened; movement: forward bending of the trunk, upper limbs lowered freely or with palms joined.*
3	*It is recommended that ATR be measured at the height of all spinous processes; the maximum value in the proximal thoracic (Th1–Th4), main thoracic (Th5–Th12) and thoracolumbar/lumbar regions should be recorded.*
4	ATR can also be measured at the level of the posterior superior iliac spines.
5	It is recommended that the range of forward bend be adjusted by the examiner during ATR measurement so that the assessed spinal segment is parallel to the ground.
6	*To confirm the result of standing ATR measurement, the procedure may be performed in the sitting position if: ATR ≥4°; in the case of leg length discrepancy (oblique pelvic alignment on clinical examination – the anterior superior iliac spine and posterior superior iliac spine are unilaterally lowered) or an inability to perform the test in the standing position (significant shortening of the muscles of the posterior thigh group, uncooperative child).*
7	It is recommended that ATR measurement be performed in a sitting position with the child's feet fully resting on the ground, knees and hips flexed at about 90°, the trunk bent forward between spread legs.
8	It is recommended to include the sitting test data in the patient's medical records.
9	It is not recommended to directly compare the sitting test results with the standing test results.
10	*A scoliometer should be used to objectify ATR measurement.*
11	Recommended reference values for interpreting ATR measured with a scoliometer during a screening test: a. 0–3° – no asymmetry/physiological asymmetry b. 4–6° – repeat the test after 3–6 months c. ≥7° – IS risk: refer the patient for further diagnosis, which may include X-ray d. the above values apply to children and adolescents.
12	When setting the screening date (observation period), the following factors should be considered: • Child's age – shorter observation period in children during the growth spurt.
13	When setting the screening date (observation period), the following factors should be considered: • growth rate (growth spurt) – shorter observation period in children before or during the growth spurt.
14	When determining the date of the screening test (observation time), the following factors should be taken into account: • gender – shorter observation period for girls.
15	When setting the screening date (observation time), the following factors should be considered: • positive family history – shorter observation period if parents or older siblings suffer from IS, especially if bracing or surgery was needed.
16	When setting the screening date (observation time), the following factors should be considered: • kyphosis (thoracic lordosis) – shorter observation period for reduced distal thoracic kyphosis.
17	When setting the screening date (observation time), the following factors should be considered: • reduced mobility of the thoracic spine in the forward bend test – shorter observation period for limited thoracic mobility during forward bend.
18	When setting the screening date (observation time), the following factors should be considered: • generalised joint laxity – shorter observation period in GJH: Beighton score ≥5 for girls and ≥4 for boys.
19	During the screening test, body height (in both standing and sitting positions) may be measured to determine the rate of spinal growth).
20	During the screening test, assessment of sagittal curves and clinical assessment of spinal mobility in the forward bend test can be performed using validated diagnostic methods and tools.
21	The screening may include GJH measurement (Beighton score).
22	It is recommended to include the date of examination, child's date of birth, gender, presence (since when)/lack of menarche in the examination report.
23	ATR can be measured using a smartphone with an appropriate application installed and a casing that reproduces the lower edge of the scoliometer, which allows for the elimination of the influence of the spinous processes on the reliability of the measurement.
24	Methods not presented here are not recommended for screening for early IS detection.
25	According to recommendation 24, surface topography imaging should not be used for early detection of IS.
26	According to recommendation 24, clinical examinations that do not use reliable tools to measure ATR but assess the position of the iliac spines and the asymmetry of the shoulder girdle and scapulae are not recommended for early IS detection.
27	In the future, ultrasound may also be used for early detection of IS. Since the usefulness of ultrasound scanners in the diagnosis of IS has not yet been fully confirmed, this approach cannot currently be recommended for screening.
28	In the future, ultra-low-dose radiation (EOS) may also prove a useful secondary screening tool (after ATR measurement) for early IS detection.

Tab. 1. Preliminary proposals for recommendations

DISCUSSION

Untreated IS can lead to trunk deformity, functional limitations and poor physical performance, resulting in a reduced quality of life. The negative consequences of IS are particularly evident with Cobb angle >30°. For Cobb angles >40°, IS may worsen in adulthood[3,24]. Early detection of this disorder is therefore crucial; however, guidelines on the validity of early detection of IS are often contradictory.

Recommendations supporting screening are based on moderate-quality evidence, whereas the recommendations against screening are based on low-quality evidence[25].

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	Who and when to screen?
1	Screening for early IS detection should be performed three times in girls: at 10, 11, and 12 years.
2	Screening for early IS detection should be performed twice in boys: at 12 and 14 years.
3	For girls who have not yet had menarche at 12 years, screening should be repeated at 12-month intervals (±3 months) until menarche.
4	A child with ATR of 0–3° as measured with a scoliometer during IS screening test does not need to undergo an additional test after 3–6 months.
5	A child with ATR of 4–6° as measured with a scoliometer during IS screening test should undergo an additional test after 3–6 months.
6	A child with ATR ≥7° as measured with a scoliometer during IS screening test should be referred for further diagnosis, which may include X-rays.
	Who should screen?
1	Screening for early detection of IS may be performed by a specialist with expertise in musculoskeletal diagnosis, especially a family doctor, a paediatrician, a specialist in medical rehabilitation, a specialist in orthopaedics and musculoskeletal traumatology, a physiotherapist, and a nurse. Following the methodological standard is the essence of proper examination.
2	According to the law, healthcare services are provided by healthcare professionals (The Act on Patient Rights and Patient Rights Commissioner of 6 November 2008, Art. 8), and the healthcare services provided should be included in the patient's medical records (Art. 24 Sec. 1 of the Act); therefore, screening should not be conducted by physical education teachers, including those specialised in corrective/compensatory gymnastics.
Recommendations modified after the discussion (before the first Delphi round) are given in italics. **ATR** – angle of trunk rotation; **GJH** – generalised joint hypermobility; **IS** – idiopathic scoliosis.	

Tab. 1. Preliminary proposals for recommendations (cont.)

Despite conflicting opinions, the leading scientific societies with expertise in IS (American Academy of Orthopaedic Surgeons, American Academy of Pediatrics, Scoliosis Research Society, SOSORT) recommend screening for early IS detection[9,19–21,26]. Furthermore, these tests meet the World Health Organization criteria for screening[27,28].

Late detection of IS and, consequently, lack of early initiation of conservative treatment, may led to high Cobb values that necessitate surgical interventions[3]. Without arguing with the rationale behind such treatment, it should be emphasised that it leads to permanent spinal stiffening and therefore cannot be considered optimal[5,6,13]. It can also lead to occupational and physical activity limitations[29]. Additionally, permanent spinal stiffening can cause overloading of segments not included in spinal fusion (spondylodesis)[30,31]. Women with a history of surgical IS treatment in their youth are more likely to give birth by caesarean section[32].

To avoid these consequences, IS should be diagnosed as early as possible.

Demonstrating that a given condition may be treated effectively in its early stages is an important element to justify screening[33]. In the case of IS, the US BRAIST Study, which showed that brace treatment in skeletally immature patients (at risk of IS progression) with a Cobb angle between 20° and 40° significantly reduced the proportion of children requiring surgery, is of key importance in this aspect[10]. Also, increasingly promising findings have been reported in studies verifying the efficacy of the so-called physiotherapeutic scoliosis-specific exercises (PSSE)[3,33–35].

For conservative treatment to be effective, it needs to be implemented at an early stage of the disorder. Optimally, it should be started at the beginning of the pubertal growth spurt, with a Cobb angle of 20–40°[3,13]. Treatment can be incorporated at lower Cobb angles, especially in the presence of factors that promote IS progression, i.e. positive family history, female gender or coexisting generalised joint hypermobility (GJH)[3,12].

Based on the analysis of guidelines from international scientific societies with expertise in IS, along with the literature and regulations on the organisation of health care in Poland, as well as using the Delphi method supported by NGT, 16 recommendations were developed and categorised into three domains: "How to screen?", "Who and when to screen?" and "Who should screen?".

It is important to adopt a standardised testing position to ensure reliability, high sensitivity and specificity of the screening test[36–40]. A scoliometer (or alternatively a smartphone with an appropriate application and casing) should be used to measure the angle of trunk rotation (ATR) for assessing dorsal asymmetry[41]. This recommendation is due to the high sensitivity and good correlation of this parameter with the gold standard in IS assessment, i.e. Cobb angle measurement[39,42]. Based on this correlation, curvature value may be predicted without invasive radiological examination[37,39,42–44] (Figs. 1 and 2).

Furthermore, ATR measurement using the scoliometer has a high internal consistency (tests performed by the same person) and external consistency (tests performed by different persons), making it useful in a clinical practice setting where it is common for the test to be performed by different specialists[38,39,45,46].

It is worth noting that since the scoliometer works on the principle of a level, it is important that the assessed part of the back is parallel to the ground. A mirror positioned to the side of the subject may be used to help the operator control the patient's torso position during the forward bend. To our knowledge, ATR could be measured only in the standing position to date. However, the clinical experience of the authors of recommendations indicates that, in certain

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No.	Recommendation How to screen?	Agreement (% of votes)	Strength of recommendation (% of votes)
1	**For the early detection of IS, it is recommended to evaluate trunk asymmetry using the Adam's forward bend test (ATR measurement).**	**100%**	**A 93%**
2	**Recommended starting position of the subject: standing with feet parallel, in line, hip width apart; knee joints straightened; movement: forward bending of the trunk, upper limbs lowered freely or with palms joined.**	**100%**	**A 93%**
3	**It is recommended that ATR be measured at the height of all spinous processes; the maximum value in the proximal thoracic (Th1–Th4), main thoracic (Th5–Th12) and thoracolumbar/lumbar regions should be recorded.**	**100%**	**A 93%**
4	**It is recommended that the range of forward bend be adjusted by the examiner during ATR measurement so that the assessed spinal segment is parallel to the ground.**	**100%**	**A 86%**
5	In the case of leg length discrepancy or if the test cannot be performed in a standing position, ATR can be measured in a sitting position.	100%	A 50%
6	It is recommended that ATR measurement be performed in a sitting position with the child's feet fully resting on the ground, knees and hips flexed at about 90°, the trunk bent forward between spread legs.	100%	A 57%
7	**A scoliometer should be used to objectify ATR measurement.**	**100%**	**A 100%**
8	**It is recommended to include the date of examination, child's date of birth, gender, presence (since when)/absence of menarche, and examination position: standing/sitting; result of three ATR measurements: 1) proximal thoracic (Th1–Th4), 2) main thoracic (Th5–Th12), 3) thoracolumbar/lumbar spine in the examination report.**	**100%**	**A 100%**
9	ATR may be measured using a mobile phone with a proper app installed and a specific case mimicking the lower edge of the scoliometer that makes it possible to eliminate the impact of spinous processes on the measurement reliability.	92.86%	A 43%
10	Methods not presented here are not recommended for screening for early IS detection.	100%	A 100%
	Who and when to screen?		
11	**Screening for early IS detection should be performed three times in girls: at 10, 11, and 12 years. For girls who have not yet had menarche at 12 years, screening should be repeated at 12-month intervals (±3 months) until menarche.**	**100%**	**A 100%**
12	**Screening for early IS detection should be performed twice in boys: at 12 and 14 years.**	**100%**	**A 100%**
13	**A child with ATR ≥7° as measured with a scoliometer during IS screening test should be referred for further diagnosis, which may include X-rays.**	**100%**	**A 100%**
14	**A child with ATR of 4–6° as measured with a scoliometer during IS screening test should undergo an additional test after 3–6 months.**	**100%**	**A 100%**
15	**A child with ATR of 0–3° as measured with a scoliometer during IS screening test does not need to undergo an additional test after 3–6 months.**	**100%**	**A 100%**
	Who should screen?		
16	**Screening for early detection of IS may be performed by a specialist with expertise in the diagnosis of the musculoskeletal system, especially a family doctor, a paediatrician, a specialist in medical rehabilitation, a specialist in orthopaedics and musculoskeletal traumatology, a physiotherapist, and a nurse.**	**100%**	**A 93%**

Recommendations that achieved the required level (≥80%) of both agreement and strength are given in bold.
ATR – angle of trunk rotation; **IS** – idiopathic scoliosis.

Tab. 2. Recommendations on how to conduct screening for early detection of idiopathic scoliosis

situations, this position may reduce the reliability of the results or make the screening impossible. However, standing position should be used as the standard position for ATR measurement (recommendations 1 and 2). It should also be the position of choice in the case of lower limb length discrepancy, in which case such asymmetry should be compensated by placing a shim of an appropriate height under the foot of the shorter limb. Screening in the sitting position may be performed in exceptional situations, which include: 1) oblique pelvic orientation (anterior and posterior superior iliac spine and iliac plate lower on the same side), 2) limited ability to perform a proper forward trunk bend due to shortening of posterior thigh muscles, 3) uncooperative child, 4) inability to maintain the recommended standing position during the examination. However, it should be emphasised that both of these recommendations did not reach the required strength, and therefore we believe that their use should be left to the discretion of clinicians, depending on the specific clinical situation.

Collecting history is a standard element of screening. It is essential to collect data important for assessing the risk of IS or its progression (family history of IS, including the degree of kinship, degree of curvature, and treatment used)[3,13,24].

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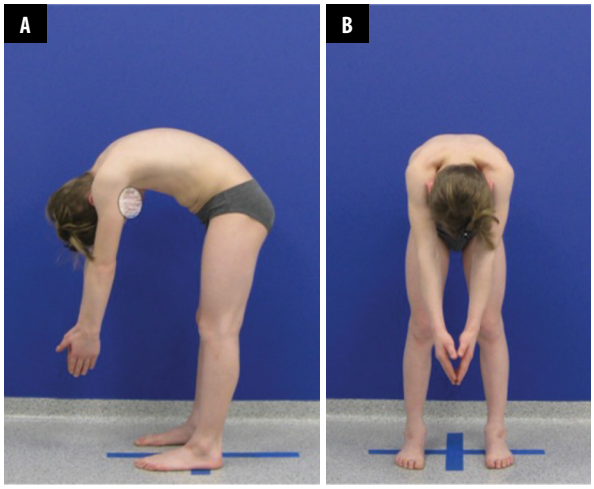

Fig. 1. Standardised position recommended for ATR measurement: **A.** *position of the subject – side view,* **B.** *position of the subject – front view*

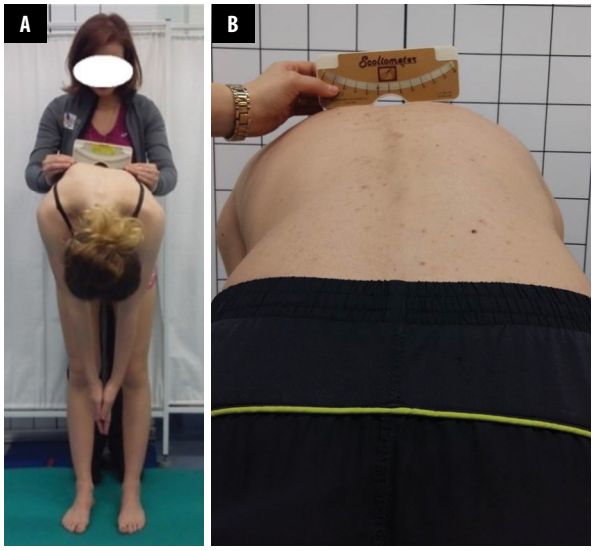

Fig. 2. ATR measurement: **A.** *front view,* **B.** *exemplary measurement result – 5° right trunk asymmetry*

Clearly defined population is one of the important features of screening[27,28]. Therefore, the discussed recommendations specify who and when should be included in the screening.

In the Polish healthcare system, developmental screening of a child is performed by a paediatrician at 8–9 years and then between 12–13 years[47]. The interval between developmental check-ups makes it easy to miss the pubertal growth spurt, when IS usually develops and worsens[9].

Although IS may develop at any stage of child's development, it is particularly common during periods of more rapid growth. The greatest change in the rate of IS progression is seen at the onset of puberty. After approximately two-thirds of the entire pubertal growth spurt period, girls experience their menarche (12–13 years of age), which is associated with a gradual reduction in the risk of IS progression[48,49]. A study among Polish children and adolescents showed that growth rates begin to increase at 9 years and 6 months in girls and at 10 years and 3 months in boys. The largest 12-month height increments (6.8 cm in girls and 7.5 cm in boys) are recorded between 128 and 140 months of age (10 years and 8 months to 11 years and 8 months) in girls, and between 150 and 161 months of life (12 years and 6 months to 13 years and 6 months) in boys[50,51].

Since female gender is associated with a higher risk of IS progression[3,24,52–54], girls should be screened more frequently than boys.

An ATR ≥7° is a recommended cut-off point for screening. This is because at this value, the sensitivity of detecting IS with a Cobb angle of 20° is 83%, while the specificity is 86%. Adopting a lower criterion (ATR = 5°) would have a higher sensitivity (100%), but unacceptable specificity (47%), with the risk of referring healthy children for further diagnosis, including X-rays[11,13,55–57].

A child with an ATR 4–6° should be referred for additional follow-up (irrespective of the standard test dates – recommendations 11 and 12). The length of observation period depends on: 1) peak height velocity (PHV), with shorter observation period for children in pubertal growth spurt; 2) a positive family history, with a shorter observation period in the case of a positive IS history in parents or siblings, especially if they required bracing or surgical treatment; 3) absence of thoracic kyphosis, with a shorter observation period in lordotization of the lower thoracic spine; 4) limited thoracic mobility, especially its lower part, in the bending direction; 5) GJH.

Given the above, screening can be supplemented with: 1) measurement of body height; 2) assessment of the size of the thoracic kyphosis and the mobility of this segment in the direction of flexion[58,59]; 3) assessment for GJH. For this purpose, for example, the Beighton scale can be used, with a score of ≥5 for girls and ≥4 for boys as a diagnostic criterion[60,61]. However, it should be emphasised that the need for additional tests depends on the decision of the person performing the screening test.

The recommendations clearly define how to perform the screening in order for it to be reliable. Therefore, in order to ensure high quality screening, to avoid both false-positive and false-negative results, as well as to optimise the costs of such testing, the Team does not recommend screening based on visual qualitative assessment of posture, including assessment of spinous process lines and shoulder/scapular asymmetry, due to its low sensitivity and specificity.

Furthermore, the screening should be performed by qualified, competent persons to actually increase early detection of IS. It is also important that testing may be performed by as large a group of professionals as possible to increase its accessibility.

Therefore, the Team assessed the possibility of screening by physical education teachers specialising in corrective/compensatory gymnastics. However, since screening for early detection of IS is a medical service provided within the Medical Activities Act, it can only be performed by medical professionals. This examination cannot therefore be

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conducted by a physical education teacher specialised in corrective/compensatory gymnastics[62].

Clinical significance of the recommendations and strengths of the study

In our opinion, the guidelines developed are the first to not only describe how to measure ATR and how to interpret the obtained result, but also to indicate which population and at what frequency should be screened. The guidelines are also the first to specify who can perform the screening, considering professional competence and the healthcare law in Poland.

The interdisciplinary nature of the Team, which included professionals with high clinical and scientific authority, is the asset of this study. It is also important that the recommendations were developed by a panel of experts representing a variety of centres, providing healthcare services both based on the general insurance system and commercially. Additionally, the experts came from a variety of clinical backgrounds, which allowed the recommendations to include different points of view.

The combined use of the Delphi method and NGT was another asset of our research. The Delphi technique allows for the expression of an anonymous opinion, independent of the other members of the Team, whereas NGT allows for discussing any concerns and exchanging arguments, which allowed for the optimal definition of recommendations from the perspective of different healthcare professionals[15–18,63]. However, the role of the Team Chairman, whose task is to control the discussion so that each member could freely express their opinion, is important in NGT[18].

CONCLUSIONS

1. Screening for early IS detection should be performed using reliable diagnostic tools and methods with proven sensitivity and specificity to minimise the rate of false-negative and false-positive results. These criteria are met by scoliometer ATR measurement.
2. ATR ≥7° is the recommended cut-off point for screening using the scoliometer.
3. In order to ensure effective, early detection of IS, it is recommended that a standard be used that defines how the test should be performed, how the results should be interpreted, as well as who and when should be tested.

Conflict of interest

The authors do not report any financial or personal connections with other persons or organisations which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

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Author contributions

Original concept of study: DC, MT, AD, JL, MK, JB, ŁS, AKG, BK, AK, AS, DK, PP, KK, TK. Collection, recording and/or compilation of data: DC, MT, AD, JL, MK, JB, ŁS, AKG, BK, AK, AS, DK, PM, TK. Analysis and interpretation of data: DC, MT, AD, JL, MK, JB, ŁS, AKG, BK, AK, AS, DK, PP, PM, TK. Writing of manuscript: DC. Critical review of manuscript: DC. Final approval of manuscript: DC, MT, AD, JL, MK, JB, ŁS, AKG, BK, AK, AS, DK, PP, PM, KK, TK.

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