ORIGINAL ARTICLE

Should screening for scoliosis be conducted?

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Abstract: **This review provides an overview of the new evidence on the use of school screening for adolescent idiopathic scoliosis (AIS), in response to the concerns of the United States Preventive Services Task Force.**

School scoliosis screening, if carefully designed and planned, can effectively detect AIS patients with significant curvature. A tandem use of screening methods in addition to the conventional forward bending test may improve screening effectiveness. School scoliosis screening continues to be an effective platform for early conservative treatment of AIS.

Keywords: **adolescents, scoliosis, screening**

I - THE CONTROVERSY OF SCHOOL SCOLIOSIS SCREENING

The use of school scoliosis screening for early detection of idiopathic scoliosis was started in the late 1950s, when the first screening programme was implemented in the state of Delaware of the United States (US) [1]. Over the past 60 years, screening programmes of different designs have been developed and implemented across different places of the world [2]. However, school scoliosis screening has been a topic of continual debate. It is often supported by clinicians under the belief that early detection renders the application of non-operative treatments effective and thus minimizes the risk of requiring invasive fusion surgery. This belief, on the other hand, has been responded with the criticism of the lack of effective screening protocol and non-operative treatments.

In 1996, the well-respected and authoritative US Preventive Services Task Force (USPSTF) made its first recommendation of insufficient evidence to either support or oppose scoliosis screening [3]. The recommendation was changed in 2004 to against screening, based on the grounds that: 1) the accuracy of screening tests for adolescent idiopathic scoliosis (AIS) was a variable; 2) most cases detected by screening will not progress to a clinically significant form of scoliosis; and 3) the health benefits of conservative treatments remained uncertain [4]. However, this recommendation was criticized to be a change of position in the absence of a change of evidence [5], and it has been recently given the lowest grade of evidence [6]. Since then, a number of high quality systematic reviews and studies have been published. Therefore, we aimed to provide an overview of the new evidence on the use of school screening for adolescent idiopathic scoliosis (AIS), in response to the concerns of the USPSTF.

II - EVIDENCE FROM SYSTEMATIC REVIEW AND META-ANALYSIS

To date, there were only one systematic review and one meta-analysis that evaluated school scoliosis screening. The systematic review identified 28 studies, published between 1977 and 2004, from eight electronic databases: 16 evaluated the effectiveness, seven assessed the cost and seven focused on diagnostic accuracy of screening tests [7]. The studies came from a wide range of designs from cross-sectional to randomized controlled trial (RCT), based on which the review concluded that there was a fair level of evidence that school scoliosis screening was safe, reduced surgery, and was cost-effective. In addition, screening only girls at 12-year-old because of the higher prevalence in girls and the use of a combination of screening tests to increase the screening accuracy were also suggested.

The meta-analysis identified 36 cohort studies published between 1977 and 2005, after a systematic search of three complementary electronic databases without any language restriction [2]. This study was recently graded as 2++, the highest grade of evidence among the other reviews by using the Scottish Intercollegiate Guidelines Network (SIGN) checklist for meta-analysis of cohort studies [8]. It has not reached the highest level of evidence which is only attainable when RCTs are considered [9]. However, the RCT design is inadequate for evaluating the accuracy of school scoliosis screening because randomization is unnecessary for obtaining the accuracy measures and the design is inapplicable to evaluate the effectiveness of a scoliosis screening programme when it has been implemented as a community based programme [2]. Consequently, the cohort design at the next highest level of evidence becomes the best design for evaluating school scoliosis screening. The screening tests utilized in these 36 studies, together with another one subsequently published, are summarized by their geographical regions in Table I. All studies in North America, Middle East and Australia used the most common forward bending test (FBT) with or without measuring the angle of trunk rotation (ATR). Studies in Europe used similar screening procedures except for one in Denmark where Moiré topography was used in addition to the FBT. In East Asia, Moiré topography was also employed in Beijing and Hong Kong, whereas Japan also used low dose roentgenography for screening AIS.

Based on the 36 studies, the pooled referral rate for radiography was 5%. The pooled estimated percentage of referred

  - DOI 10.1007/s12240-012-0040-3

Table I: A SUMMARY OF SCREENING TESTS UTILIZED ACROSS DIFFERENT REGIONS IN THE WORLD.

Screening test(s) utilized*	Region**				
	North America (n=9)	Europe (n=12)	Middle East (n=6)	East Asia (n=9)	Australia (n=1)
FBT	6 (67%)	8 (67%)	6 (100%)	2 (22%)	1 (100%)
FBT + ATR	3 (33%)	3 (25%)	0 (0%)	3 (33%)	0 (0%)
FBT + Moiré topography	0 (0%)	1 (8%)	0 (0%)	0 (0%)	0 (0%)
FBT + ATR + Moiré topography	0 (0%)	0 (0%)	0 (0%)	2 (22%)	0 (0%)
Moiré topography + Low-dose roentgenography	0 (0%)	0 (0%)	0 (0%)	2 (22%)	0 (0%)

* FBT = Forward bending test, ATR = Angle of trunk rotation.
** North America included Canada, and United States; Europe included: Athens, Bulgaria, Denmark, England, Greece, Netherlands, Spain, and Turkey; Middle East included: Israel, Jordan, and Saudi Arabia; East Asia included: Mainland China, Hong Kong, Japan, and Singapore.

students with Cobb angle ≥ 10° detected was 28% and that with Cobb angle ≥ 20° was 5.6%. These positive predictive values (PPVs) are clearly low, indicating many students were unnecessarily referred. However, there has been substantial heterogeneity across the studies in terms of their reported prevalence of AIS, referral rate for radiographic diagnosis, and PPV. One factor contributing to the study heterogeneity is the use of different screening tests. Specifically, the use of the FBT as the only screening test has been meta-analytically shown to be insufficient. It largely increased the odds of referral for radiography by almost 200%, and at the same time reduced the odds of PPV for detecting ≥ 10° curves by around 50% and that for detecting ≥ 20° by 66%. Thus, using the FBT alone would unnecessarily refer many students to receive radiographic assessment. This echoes the concern of the USPSTF on the varied reported effectiveness of the FBT.

It is well known that idiopathic scoliosis commonly presents during the few years of adolescent growth spurt but the exact time of onset remains variable. For example a young girl screened negative for scoliosis at the age of 10 may develop scoliosis at the age of 10.5 years or 11-years-old. Thus follow-up information of screened students until their skeletal maturity is desirable. Until 2010, there had been only one such study, but it had only screened 2,242 students and referred 92 for radiographic assessment. It is therefore desirable to have larger scale studies with sufficient follow-up information of students for more reliable and representative estimates of screening accuracy. In response to this, a series of evaluations on the Hong Kong scoliosis screening programme has been reported and an overview of findings is provided.

III - SCHOOL SCOLIOSIS SCREENING IN HONG KONG

School scoliosis screening in Hong Kong was started in November 1995 and guided by a protocol developed by the senior author (KDKL) of the Department of Orthopaedics and Traumatology of the University of Hong Kong [10]. It is a voluntary programme which is part of an annual national health assessment scheme managed by the Department of Health.

Students studying Grades 5 to 9 are eligible to the Hong Kong scoliosis screening programme, which comprises three tiers (Fig. 1). Students in tier 1 are assessed by the FBT and measurement of the angle of trunk rotation (ATR). Those with ATR between 5° and 14° are referred to tier 2 where they are also assessed by the Moiré topography. Students with ATR ≥ 15° are directly referred for radiographs without going through the tier 2 Moiré. Students in tier 2 are referred for radiographs when they have 2 or more Moiré lines difference between the ▷▷

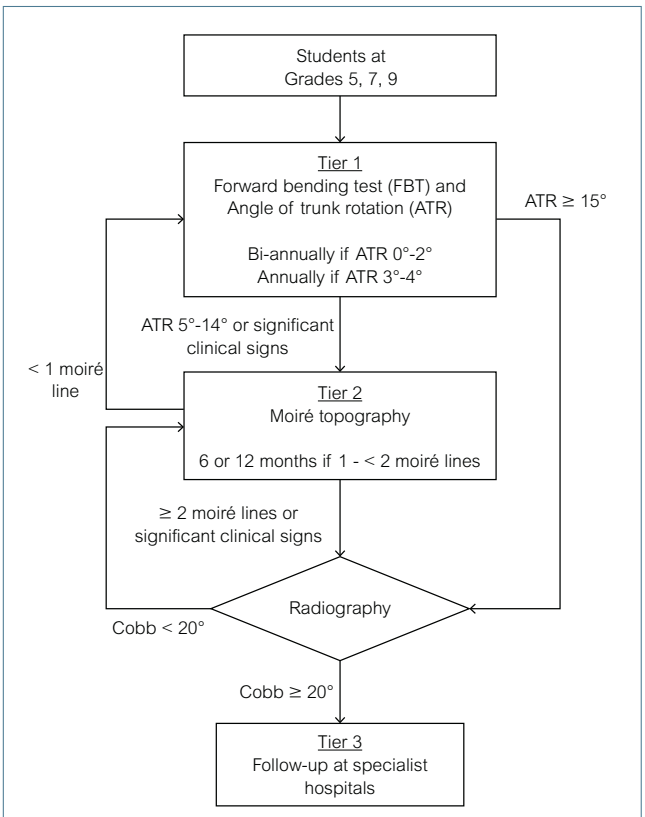

Figure 1: Assessment flow chart of the Hong Kong scoliosis screening programme.

▷▷ left and right side, or significant clinical signs. Only students who have Cobb angle ≥ 20° are moved into tier 3 which is a follow up at a specialist hospital. If the Cobb angle was < 20° the student will be looped back into the tier 2 Moiré reassessment every 6 months. In all tiers, students are also assessed by clinical signs and re-assessed on a schedule depending on their degree of AIS indication.

IV - ACCURACY OF SCHOOL SCOLIOSIS SCREENING

The evaluation of the scoliosis screening programme in Hong Kong was based on 115,190 students who were studying Grade 5 during the academic years of 1995/1996 and 1996/1997, and participated in the programme. It utilized follow-up information of students through their skeletal maturity, taken as the age of 19 years. A total of 3,228 (2.8%) were referred for radiography; of which, 81% had Cobb angle ≥ 10° and 44% had Cobb angle ≥ 20°. These PPVs are much higher than the corresponding pooled estimates obtained from the other earlier cohort studies. Moreover, they are also within or even above the common range of 30% to 50% in a community based screening programme [11]. Nevertheless, the PPVs are not expected to be very high because of the low prevalence of AIS, which was 2.5% for curves ≥ 10° and 1.4% for curves ≥ 20°. Sensitivity is the proportion of the concerning cases detected. It is a more generalizable accuracy measure which is not influenced by the prevalence. For the Hong Kong scoliosis screening programme, the sensitivity was 91% for detecting ≥ 10° curves and 88% for detecting ≥ 20° curves, both of which exceed the usual minimal standard of 70% to 80% [11]. The specificity and negative predictive value were consistently above 95% and are generally not a concern for evaluating the accuracy of school scoliosis screening.

The accuracy of different combinations of screening tests was also assessed [12]. The use of Moiré topography in addition to the FBT and ATR assessment increased the referral rate and thus moderately reduced the PPV. However, these are more than compensated by a substantial increase in sensitivity. The combined use of Moiré topography, FBT and ATR are essential for the screening programme to be accurate with few over-referrals. Moreover, lowering the current threshold of ATR ≥ 15° for direct referral of students to receive radiography increased referrals and thus reduced the PPV but had only a very small increase in sensitivity. If we used the threshold of ATR ≥ 5° which had been commonly adopted in other screening programmes, the referral rate would be largely increased to 8.3% and the PPV would be substantially reduced to 15% although the sensitivity would be increased to 95%. The current threshold of ATR ≥ 15° to bypass tier 1 resulted in a good balance of referral rate, PPV and sensitivity. Furthermore, 9% of girls had ≥ 20° curvature when first detected before the age of 12 years but it was only 1% in boys. This may be due to the slightly later onset of puberty in boys than girls. Thus, boys may have screening started at an age later than 12 mostly when they are in Grade 12.

Overall, the Hong Kong scoliosis screening programme is well-designed and is effective in identifying AIS patients who require clinical monitoring. It had a higher sensitivity than another scoliosis screening programme in Rochester, Minnesota, which was the only other screening programme to date that has been evaluated based on follow-up information on screened students until they have reached skeletal maturity. The Rochester programme however used the FBT and ATR assessment only.

V - COST OF SCREENING

The cost of a screening programme is an important consideration for policy makers to plan healthcare resources. Although the USPSTF did not consider the cost of screening in their recommendation statements, they did stipulate that the cost of screening AIS should cover the costs spent on screening tests, staff, treatment and follow-up [4]. In the Hong Kong scoliosis screening programme, the estimated cost of screening was US$18 per student screened and that of diagnosis and medical care were US$2 and US$35 per student screened, respectively. These result in a total of US$55 per student screened. This highly resembles the US$54 per student screened reported in the only other evaluation study of the Rochester screening programme to date that considered all the relevant costs in students followed through skeletal maturity [13]. However, the cost of picking up one student with ≥ 20° in the Hong Kong screening programme was US$2,276 and that for one treated student, inclusive of bracing and surgery as indicated, was US$20,768.

VI - CONCLUSION

Some of the current concerns regarding school scoliosis screening are due to the lack of large scale cohort studies with sufficient follow-up of screened students. Since the latest USPSTF recommendation made in 2004 against school screening for AIS, new quality evidence has emerged which addressed the concerns of the lack of effective screening programme and referring many mild curves that do not need clinical follow-up. School scoliosis screening, if carefully designed and planned, can effectively detect AIS patients with significant curvature. The use of FBT alone for detecting AIS is clearly insufficient. The Moiré topography has been rarely used for screening but its use in addition to the FBT and ATR has been shown to improve the effectiveness of school scoliosis screening. If the cost is considered as bearable, school scoliosis screening will not only be beneficial to patients requiring clinical monitoring but also provide a platform for a better understanding of the natural history of idiopathic scoliosis. However, the effectiveness of conservative treatments for AIS remains to be further studied. ●

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This study was financially supported by the Central Policy Unit of the Government of the Hong Kong Special Administrative Region (HKSAR) and the Research Grants Council of the HKSAR, China. (Project No.: HKU 7003-PPR-09)

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1. **Karachalios T, Roidis N, Papagelopoulos PJ, et al. (2000)** The efficacy of school screening for scoliosis. Orthopedics 23(4): 386-91.
2. **Fong DY, Lee CF, Cheung KM, et al. (2010)** A meta-analysis of the clinical effectiveness of school scoliosis screening. Spine 35(10): 1061-71.
3. **USPSTF (1996)** Guide to Clinical Preventive Services. 2nd ed, Office of Disease Prevention and Health Promotion, Washington, DC.
4. **USPSTF (2004)** Screening for idiopathic scoliosis in adolescents: recommendation statement, Agency for Healthcare Research and Quality, Rockville, MD.
5. **Richards BS, Vitale MG (2008)** Screening for idiopathic scoliosis in adolescents. An information statement. J Bone Joint Surg Am 90(1): 195-8.
6. **SIGN (2008)** SIGN 50: A guideline developer's handbook, Scottish Intercollegiate Guidelines Network, Edinburgh, UK.
7. **Sabirin J, Bakri R, Buang SN, et al. (2010)** School scoliosis screening programme-a systematic review. Med J Malaysia 65(4): 261-7.
8. **Plaszewski M, Nowobilski R, Kowalski P, et al. (In Press)** Screening for scoliosis: different countries' perspectives and evidence-based health care. Int J Rehabil Res.
9. **Obremskey WT, Pappas N, Attallah-Wasif E, et al. (2005)** Level of evidence in orthopaedic journals. J Bone Joint Surg Am 87(12): 2632-8.
10. **Luk KD, Lee CF, Cheung KM, et al. (2010)** Clinical effectiveness of school screening for adolescent idiopathic scoliosis: a large population-based retrospective cohort study. Spine 35(17): 1607-14.
11. **Glascoe FP (2005)** Standards for Screening Test Construction. American Academy of Pediatrics, http://www2.aap.org/sections/dbpeds/practice-screening.asp.
12. **Lee CF, Fong DY, Cheung KM, et al. (2010)** Referral criteria for school scoliosis screening: assessment and recommendations based on a large longitudinally followed cohort. Spine 35(25): E1492-8.
13. **Yawn BP, Yawn RA (2000)** The estimated cost of school scoliosis screening. Spine 25(18): 2387-91.

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