2009 MOH/P/PAK/186.09/(TR)

HEALTH TECHNOLOGY ASSESSMENT REPORT

MINISTRY OF HEALTH MALAYSIA

SCHOOL SCOLIOSIS SCREENING PROGRAMME

Health Technology Assessment Section (MaHTAS)

Medical Development Division, Ministry of Health Malaysia

Level 4, Block E1, Parcel E, Government Offices Complex,

62590 Putrajaya, MALAYSIA

MINISTRY OF HEALTH MALAYSIA

Health Technology Assessment Report

SCHOOL SCOLIOSIS SCREENING PROGRAMME

DISCLAIMER

This Health Technology Assessment has been developed from analysis, interpretation and synthesis of scientific research and/or technology assessment conducted by other organizations. It also incorporates, where available, Malaysian data, and information provided by experts to the Ministry of Health Malaysia. While effort has been made to do so, this document may not fully reflect all scientific research available. Additionally, other relevant scientific findings may have been reported since completion of the review.

Please contact : www.htamalaysia@moh.gov.my, if you like further information.

For further information please contact:
Health Technology Assessment Section (MaHTAS),
Medical Development Division
Ministry of Health Malaysia
Level 4, Block E1, Precinct 1
Government Office Complex
62590 Putrajaya
Tel: 603 88831246
Fax: 603 8883 1230

Available at the following website:
http://www.moh.gov.my,

AUTHORS

Dr. Junainah Sabirin
Principal Assistant Director
Health Technology Assessment Section (MaHTAS)
Medical Development Division
Ministry of Health Malaysia

Dr. Saidatul Norbaya bt Buang
Principal Assistant Director
School Health Unit
Family Health Section
Family Health Development Division
Department of Public Health
Ministry of Health Malaysia

EXPERT COMMITTEE

Dr. Hj. Ahmad Tajuddin bin Abdullah
Consultant Orthopaedics and Head of Department
Orthopaedic Department
Tengku Nurzahirah Hospital, Terengganu

Dr. Mymoon bt Alias
Deputy Director
Family Health Section
Family Health Development Division
Department of Public Health
Ministry of Health

Dr. Azmi bin Dato' Baharudin
Head, Spinal Unit
Orthopaedic Department
UKM Medical Centre
The National University of Malaysia

Dr. Abdul Halim bin Yusof
Lecturer, Spinal Unit
Orthopaedic Department
School of Medical Sciences
Health Campus USM
University Science of Malaysia

Dr. Hanun Fauziah bt Abd. Ghani
Consultant and Head of Diagnostic and Imaging Services
Serdang Hospital

Dr. Azlin bt Amat
Family Medicine Specialist
Kuala Terengganu
Health Office
Terengganu

REVIEWERS

Professor Dato' Dr. Mohamad Abdul Razak
Deputy Vice Chancellor (Student Affairs and Alumni)
Universiti Kebangsaan Malaysia

Dr. Fazir Mohamad
Consultant Orthopaedic and Head of Spine Unit
Orthopaedic Department
Kuala Lumpur Hospital

Professor Dr. Sharaf Ibrahim
Paediatric Orthopaedic Surgeon
Universiti Kebangsaan Malaysia

Associate Professor Dr. Kwan Mun Keong
Head of Spine Unit
Department of Orthopaedic Surgery
University of Malaya Medical Center

Datin Dr. Rugayah Bakri
Head, Health Technology Assessment Section (MaHTAS),
Deputy Director
Medical Development Division
Ministry of Health Malaysia

ACKNOWLEDGEMENT

The authors for this Health Technology Assessment Report would like to express their gratitude and appreciation to the following for their contribution and assistance:

- Health Technology Assessment and Clinical Practice Guidelines Council.
- Technical Advisory Committee for Health Technology Assessment.
- Technical Committee for Scoliosis Screening in Schools.
- Mr Sahaludin Sharif, Madam Zalina Ahmad, Madam Rosnah Siran from MaHTAS for their contribution in retrieval of the evidence and Miss Sebrina Su Hiu Choo from Institute for Health Systems Research for her contributions in editing this report.

DISCLOSURE

The authors of this report have no competing interest in this subject and the preparation of this report is totally funded by the Ministry of Health, Malaysia.

EXECUTIVE SUMMARY

Background

Scoliosis is a lateral curvature of the spine greater than 10° as measured using Cobb method on a standing radiograph. Adolescent idiopathic scoliosis is the most common form of idiopathic scoliosis. The prevalence of adolescent idiopathic scoliosis varies according to the Cobb angle, between 0.1% in curvature greater than 40° Cobb angle to 2% to 3% in curvature greater than 10° Cobb angle. Severe scoliosis may have significant impact on physical and psychosocial disorders such as a decrease in pulmonary capacity, back pain and lower marriage rate. School scoliosis screening in asymptomatic school children remains controversial with some countries advocating it and others are against it.

Technical features

The traditional methods such as Adams forward-bending test, the assessment of the angle of trunk rotation by scoliometer, Moire topography, and the measurement of rib hump are the most common screening tests for scoliosis, worldwide.

Objective

To assess the effectiveness and economic implications of school scoliosis screening programme.

Methods

Electronic databases such as MEDLINE, PubMed, EBM Reviews-Cochrane Database of Systematic Reviews, EBM Reviews-Cochrane Central Register of Controlled Trials, EBM Reviews-HTA databases, EBM Reviews-NHS Economic Evaluation Database, EBM Full Text-Cochrane DSR, ACP Journal Club and DARE were searched. There was no limitation in the search. All relevant literature was appraised using the Critical Appraisal Skills Programme (CASP) and evidence was graded based on guidelines from U.S./Canadian Preventive Services Task Force or Hierarchy of evidence for test accuracy studies, CRD Report Number 4 (2nd Edition).

Results and conclusion

Girls achieve adolescence two years before boys and are afflicted with scoliosis three to four times more frequently than boys. This statement is supported by this review. The prevalence of scoliosis was higher in girls compared to boys. Prevalence in girls was low for six to ten years of age but increased rapidly from eleven to fourteen years of age.

There was fair level of evidence to suggest that school scoliosis screening programme was able to detect scoliosis at a younger age and with smaller Cobb angle and was able to reduce the frequency of surgical treatment. The cost of screening a child ranged from USD $0.07 to USD 43.70 depending on how it was calculated. There was also evidence to suggest that school scoliosis screening programme was cost-effective.

There was fair level of evidence to suggest that Adams forward-bending test, measurement of angle of trunk rotation using scoliometer, measurement of rib hump height using humpometer and Moire topography can be used as a screening test for scoliosis screening in schools and is not time consuming. However, the use of Adams forward-bending test may result in high false negatives which may lead to miss-diagnosis while the use of other screening tests such as scoliometer, Moire topography and humpometer may lead to high false positives and will cause over-referrals. Few studies have suggested that the use of cut off limits for referrals such as asymmetry of two Moire fringes, a humpogram deformity = 10 mm, and 7° or 8° of scoliometer angle would lead to a reduction in the number of referral for radiographic examination.

There was evidence to suggest radiographic examination for scoliosis follow-up was safe. Proper training of the staff involved in the screening is necessary together with a good referral and follow-up system based on ethical and organisational consideration.

Recommendation

Based on the above review, screening for scoliosis among school children is recommended only for high risk group such as girls at twelve years or age (standard six). A combination of modalities of screening tests such as Adams forward-bending test and scoliometer with angle of trunk rotation of 7° is recommended with the aim of reducing the number of referrals. However, organisational issues such as training, manpower, good referral system, treatment and funding need to be addressed at all levels.

TABLE OF CONTENTS

GLOSSARY

Girls	:	Females from six to 19 years old
Boys	:	Males from six to 19 years old
SRS	:	Scoliosis Research Society
AIS	:	Adolescent idiopathic scoliosis
AAOS	:	American Academy of Orthopaedic Surgeons
POSNA	:	Paediatric Orthopaedic Society of North America
AAP	:	American Academy of Paediatrics
ATR	:	Angle of trunk rotation
RHH	:	Rib hump height
RCT	:	Randomised controlled trial
Yrs	:	Years
CI	:	Confidence interval
CSS	:	Complimentary screening session
OR	:	Odds ratio
USD	:	US dollar
CAD	:	Canadian dollar
PPV	:	Positive Predictive Value
NPV	:	Negative predictive Value
AUC	:	Area under receiver operating characteristic curve

HEALTH TECHNOLOGY ASSESSMENT SCHOOL SCOLIOSIS SCREENING PROGRAMME

1 BACKGROUND

The Scoliosis Research Society (SRS) has defined scoliosis as a lateral curvature of the spine greater than 10 degrees (10°) as measured using the Cobb method on a standing radiograph. Idiopathic scoliosis is the most common form of lateral deviation of the spine. Idiopathic scoliosis is a structural curve with no clear underlying cause. It usually becomes evident in the early adolescent years and although significant progress has been made in the genetic study of this disorder, its cause presently remains unknown, thus the label "idiopathic" scoliosis. Idiopathic scoliosis is classified based on the age of the patient when it is first identified. Infantile scoliosis has an onset before three years of age. The infantile form accounts for less than one percent of all cases. Juvenile scoliosis is first detected between three and ten years of age. The juvenile form occurs in 12 to 21 percent of all patients with idiopathic scoliosis. Adolescent idiopathic scoliosis is found between ten years of age and skeletal maturity. The adolescent form accounts for the majority of cases of idiopathic scoliosis. Curve progression is unpredictable, though a subset of children with adolescent idiopathic scoliosis may exhibit rapid progression.[1]

The prevalence of adolescent idiopathic scoliosis (AIS), defined as a curvature greater than 10° according to Cobb angle, is 2% to 3%. The prevalence of curvatures greater than 20° is between 0.3% to 0.5%, while the prevalence of curvatures greater than 30° is approximately 0.2% and curvatures greater than 40° Cobb angle is found in less than 0.1% of the population. The ratio of girls to boys with small curves of 10° is equal but increases to a ratio of 10 girls for every one boy with curves greater than 30°. Scoliosis in girls tends to progress more often and, therefore girls more commonly need treatment compared to boys. Once the diagnosis of scoliosis has been made, the primary concerns are the presence of an underlying cause and whether the curvature will progress. The three main determinants of progression are patient gender, future growth potential and the curve magnitude at the time of diagnosis. Secondary causes of scoliosis can usually be identified by radiography and clinical examination.[1]

Spinal disorders can have a significant impact on the physical and psychosocial health of affected individuals. Curve pattern has some predictive value in the development of complications; thoracic curve are more likely to produce pulmonary compromise and lumbar curves are more likely to produce postural problems. The deformity of the chest cavity produced by the rotation of the thoracic vertebral body produces a rib hump along with narrowing of the space available for pulmonary expansion. Studies have reflected changes in pulmonary function in correlation with the magnitude of the curvature whereby a decrease in pulmonary capacity has been seen in patients with curves greater than 60°. Midthoracic curves can be associated with back pain, generally felt over the apex of the curve, which is fatiguing in nature but not disabling. A lower marriage rate and lack of participation in social functions inferred that scoliosis sufferers have poor self-image and social isolation.[2]

Every year, thousands of operations are performed for the primary diagnosis of adolescent idiopathic scoliosis in patients between the ages of 10 to 18.[3] One of the most popular methods for prevention of these complications is early detection through screening of school children. This was first conducted in the Delaware public schools in 1962.[2] Screening is the presumptive identification of unrecognized disease or defect by the application of tests, examinations, or other procedures that can be applied rapidly. Beginning 1984, the American Academy of Orthopaedic Surgeons (AAOS) and the SRS endorsed the concept of school screening for the early detection of scoliosis in children whose deformities may have gone unnoticed. This endorsement was based on the assumption that early detection in children at risk for worsening would lead to the institution of non-operative treatments that could have a positive impact on the long-term natural history of this disorder. Without treatment many curves could be expected to worsen over the long-term, with some eventually needing surgical intervention. In addition, more significant scoliosis in children who may present with no other symptoms could be detected by clinical screening at the time when surgical treatment for their deformity could be performed most effectively. On average, girls achieve adolescence two years before boys and are afflicted with scoliosis three to four times more frequently than boys. As a result, the AAOS, SRS, Paediatric Orthopaedic Society of North America (POSNA) and American Academy of Paediatrics (AAP) agree that if scoliosis screening is undertaken girls should be screened twice, at age 10 and 12 (grades 5 and 7), and boys once, at age 13 or 14 (grades 8 or 9).[3]

Many devices and techniques have been used for screening of scoliosis among school children. This includes the Adams forward-bending test and quantitative evaluations of deformity such as measurement of rib hump height using a level and a ruler, Moiré topography, and scoliometer. However, none of these techniques is diagnostic. Radiographs are required to establish the diagnosis, aetiology and severity of spinal deformity.[4]

Routine clinical screening for scoliosis continues to be controversial with less than half of the United States (U.S.) currently legislating school screening. In 1996, the U.S. Preventive Services Task Force released its opinion on screening for adolescent idiopathic scoliosis. The Task Force noted that there was insufficient evidence for or against routine screening of asymptomatic adolescents for idiopathic scoliosis. Subsequently in 2004, the U.S. Preventive Services Task Force recommended against the routine screening of asymptomatic adolescents for idiopathic scoliosis, not on the grounds of new evidence, but by changing the methodology of rating existing evidence.[5]

In Japan, school screening programme for scoliosis is mandatory by law. On the contrary, the British Orthopaedic Association and the British Scoliosis Society concluded that it should not be a national policy to routinely screen children for scoliosis throughout the United Kingdom.[5]

At present, scoliosis screening is not part of the Malaysian School Health Service. As a result, cases of scoliosis are often detected late, only when it becomes symptomatic and require corrective surgical procedures. A study conducted in Kuala Lumpur Hospital by Chuah *et al*. among 152 patients demonstrated that the median rate of curve progression of untreated idiopathic scoliosis curves was 7.03° per year. The mean age at presentation for idiopathic scoliosis was 15.5 years (3.7 to 29.9 years) and the mean curve size at presentation was 41.6° (5° to 110°). The mean age of surgery for idiopathic scoliosis was 15.69 years (7.25 to 43.92 years), the mean pre-operative curve was 66.42° (37° to130°) and the mean post-operative curve was 36.82° (15° to 79°).[6] A cross sectional study on screening for scoliosis among 2,630 school children aged 11 to 15 years old in Kuala Terengganu was conducted between May and July 2004 by Azlin A. The prevalence of scoliosis was found to be 1.44% and increased with age; 1.36% in 11 years old and 4.14% in 15 years old and the ratio of girls to boys was 3:2.[7]

This technology review was conducted following a request from School Health Unit, Family Health Section, Family Health Development Division, Department of Public Health under the Ministry of Health.

2 TECHNICAL FEATURES

A school screening programme for spinal deformity should consist of four basic parts: the preliminary work, the actual screening, the follow-up procedures, and the analysis of data from the programme.

The traditional methods such as Adams forward-bending test, the assessment of the angle of trunk rotation (ATR) by scoliometer, Moire topography, and the measurement of rib hump are the most common screening tests for scoliosis worldwide. In studies done elsewhere, school children found to be positive for scoliosis were subjected to posterior-anterior standing radiological examination which is the reference test for confirmation of scoliosis.[8]

2.1. Adams forward-bending test

The actual screening examination begins with the child standing straight but relaxed, with the back to the examiner, feet together, head up, and looking straight ahead with arms hanging relaxed at the sides (Figure 1A). The examiner should look for asymmetrical shoulder levels, prominence of one of the scapula, unequal distances from the arms to the flanks, an unequal waistline or high hip, centering of the head over the intergluteal cleft and lower limb length inequality.[9]

Next, is the assessment of the Adams forward-bending test (Figure 1B). With the feet together and the knees straight, the child bends at the hips to nearly 90° with the arms dangling forward, palms together. Viewed from behind and in front, both sides of the chest and both sides of the lumbar area should be at the same levels. A consistent early sign of scoliosis is an asymmetrical prominence on one side of the thoracic or lumbar area (this is caused by the vertebral rotation that usually accompanies scoliosis). Lateral deviation of the spine may also be seen best in this position.[9]

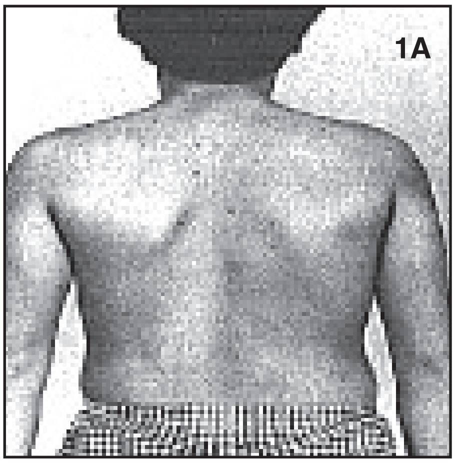


Figure 1A.
This child with right thoracic scoliosis shows scapular and waistline asymmetry and unequal arm-to-flank spaces.

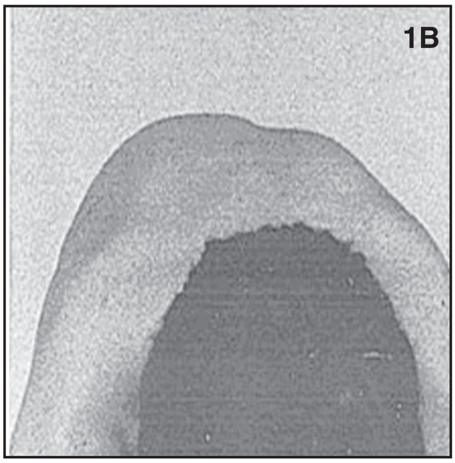


Figure 1B.
The Adams forward-bending test shows right rib rotational prominence.

When viewed from the side in the forward bending position, kyphosis may also be evident as a dorsally-directed angulation in the thoracic or thoracolumbar region (Figure 2A &2B).

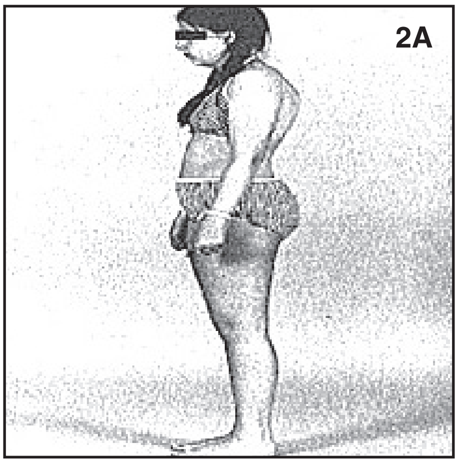


Figure 2A.
Increased thoracic kyphosis and lumbar lardosis is present in this girl.

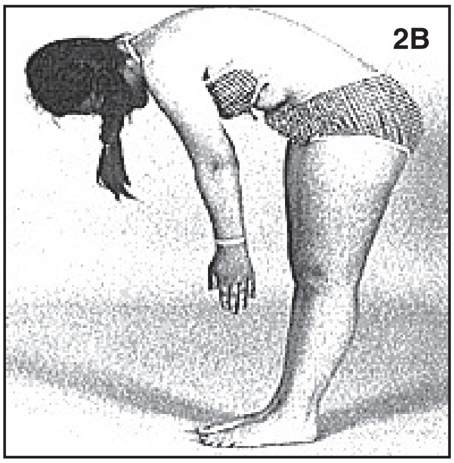


Figure 2B.
During the forward-bending test, the angular thoracic hyperkyphosis is apparent and the compensatory lumbar hyperlordosis flattens out.

2.2. Scoliometer

Measurement of ATR was described by Schulthess in 1902. As the spinal rotation meter developed, a slightly different technique came to be used. With the child in a standing, forward bent position, the meter is moved in a crania-caudal way, so that the maximal inclination of the back can be identified and recorded in whole degrees. Usually a measurement of 5° or more in all regions of the back is classified as positive.[4]

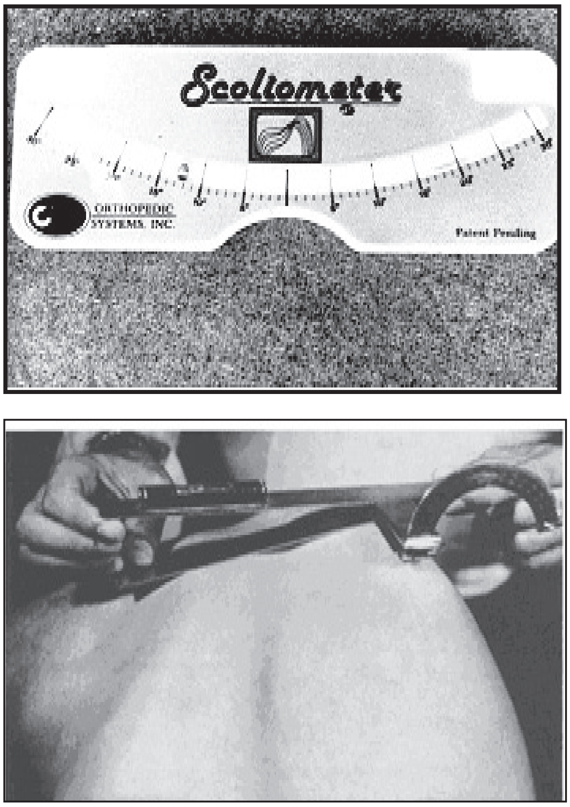


Figure 3. Scoliometer in use.

2.3. Measurement of rib hump height (humpometer)

Measurement of rib hump height (RHH) is performed with the child in a forward-bent position. A visual hump in the thoracic, thoracolumbar or lumbar region is identified. The measurement device (Figure 4) is placed symmetrically on the back by moving the vertical calibrated pointers in an equal distance from the spinous process. After controlling the horizontal balance of the meter with the spirit level indicator, the difference in height top and valley on the contralateral side of the hump can be measured in millimetres. The maximal hump is recorded.[4]

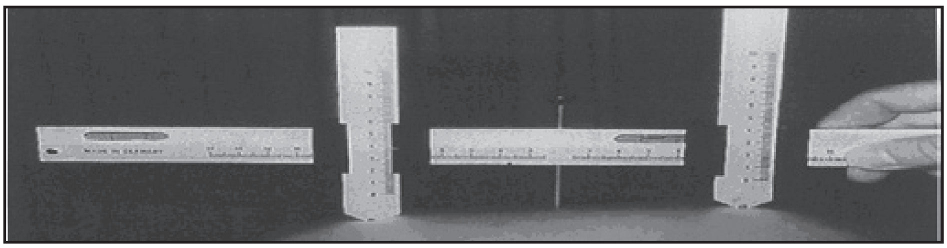


Figure 4. A device used for measuring rib hump height

2.4. Moire topography

In setting up Moire topography, three elements are essential; a screen (raster), a light source and a camera. The screen is made of Plexiglas and is painted with black parallel lines. The thickness of the lines is equal to the distance between them. The width of one line and one space is called the interval of the screen. When the screen is illuminated from an angle, an interference pattern behind it is produced. The pattern is influenced by an object placed behind the screen, and can be read. In particular, asymmetries can be quantified in line differences or in angles. The pattern can be photographed with an ordinary camera using a black and white film. The pictures are judged on line differences using a viewer and a template with parallel lines (Figure 5).[10]

Moiré topography registers a three-dimensional description of the shape of the back. In the straight spine, the moiré shadow pattern is equal on both halves of the back. In structural scoliosis, the moiré pattern differs increasingly with the increasing deformity of the spine. This asymmetry is mainly caused by the rotational component of scoliosis. The shadow patterns consist of contour-lines, which can be compared with those on a relief map. By photographing the moiré shadow lines, the status of the back is documented (Figure 6).[10]

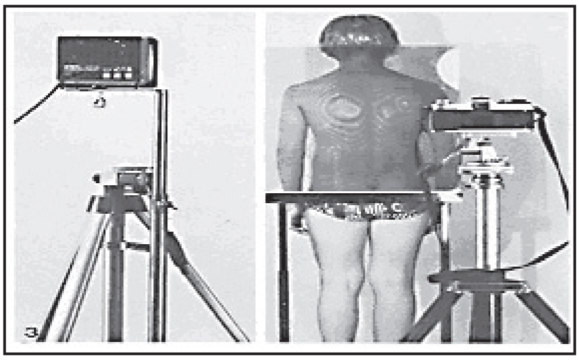


Figure 5. The moiré equipment

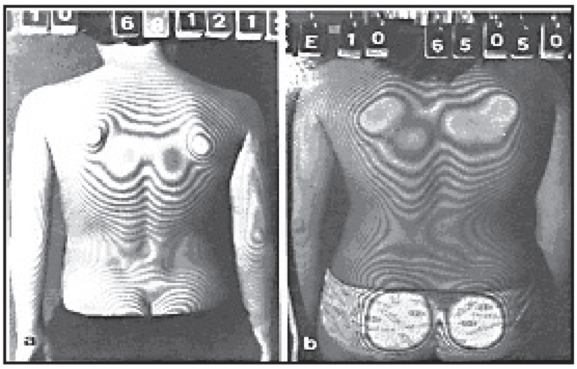


Figure 6. The moire topography of a straight back (left) and a left convex thoraco-lumbar scoliosis of 24° (right)

2.5. Radiologic evaluation (reference test)

The standard radiologic evaluation of adolescent idiopathic scoliosis consists of standing posterioranterior radiographs of the full spine. The Cobb method is used to measure the degree of scoliosis on the posterior radiograph (Figure 7).

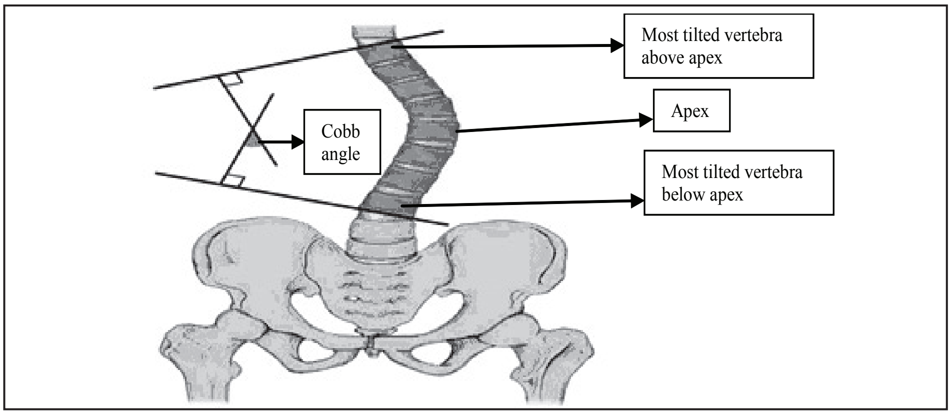


Figure 7. To use the Cobb method for measuring the degree of scoliosis, choose the most tilted vertebrae above and below the apex of the curve. The angle between intersecting lines drawn perpendicular to the top of the vertebrae and the bottom of the vertebrae is the Cobb angle.[11]

2.6. Treatment

Treatment options for patients with scoliosis range from unproven or harmful to beneficial. Bracing and spinal surgery have been proven to alter the natural history of curve progression. Curves that are 20° or less before the time of skeletal maturity are considered mild and are generally re-evaluated every six months. Curves that progress 5° to 10° and those that are more than 30° at the time of diagnosis usually are treated with a brace. A meta-analysis of the efficacy of non-operative treatments for idiopathic scoliosis by Rowe *et al.* showed that the weighted mean proportion of success was 0.39 for lateral surface stimulation, 0.49 for observation only, 0.60 for bracing for eight hours per day, 0.62 for bracing for sixteen hours per day, and 0.93 for bracing for twenty-three hours per day. The twenty-three hours regimen was significantly more successful than any other treatment ($p<0.001$).[12] The current recommendation is to wait until scoliosis approaches 30° Cobb angle before starting brace treatment.[5] The current consensus is that surgery should be performed for curves greater than 40° to 45° when there is growth remaining.[1]

3 POLICY QUESTION

Should scoliosis screening among school children be instituted in Malaysian School Health Programme?

4 OBJECTIVE

To assess the effectiveness and economic implications of school scoliosis screening programme. The following research questions were addressed:

i. To undertake a systematic review on the effectiveness and cost-effectiveness of scoliosis screening among school children

ii. To assess the diagnostic accuracy of screening tests used in scoliosis screening among school children and to recommend the best screening tests

iii. To look into the safety aspect of radiography, the social, ethical and legal aspect related to scoliosis screening among school children

5 METHODOLOGY

5.1. Literature search strategy

Electronic databases were searched for published literatures pertaining to school scoliosis screening. The following databases were searched including MEDLINE, PubMed, EBM Reviews-Cochrane Database of Systematic Reviews, EBM Reviews-Cochrane Central Register of Controlled Trials, EBM Reviews-HTA Databases, EBM Reviews-NHS Economic Evaluation Database, EBM Full Text-Cochrane DSR, ACP Journal Club and DARE. Additional articles were identified from reviewing the bibliographies of retrieved articles and hand-searching of journals. Further information was sought from unpublished report. There was no limit in the search. The following search terms were used either singly or in combination: school scoliosis screening, scoliosis screen*, school health, screening program, scoliosis, and scoliometer.

5.2. Inclusion and exclusion criteria

Based on the policy question the following inclusion and exclusion criteria were used:-

a) Inclusion criteria:-

i. Study design	:	Cross sectional, cohort, case control, randomised controlled trial (RCT) and systematic review
ii. Population	:	School children
iii. Interventions	:	Scoliosis screening using Adams forward-bending test and / or measurement of rib hump height using a level and a ruler, measurement of angle of trunk rotation using scoliometer, and Moiré topography
v. Comparators	:	No screening
vi. Outcomes	:	Primary outcome:- Detection rate, frequency of idiopathic scoliosis surgery, progression of idiopathic scoliosis, number needed to screen to identify one child with scoliosis, costs of performing screening programme, diagnostic accuracy of different screening tests used in school scoliosis screening and safety of radiography during follow-up. Secondary outcome:- The final outcome measure depended on the literature retrieved and included cost per quality adjusted life year (QALY) gained.

b) Exclusion criteria
Adult scoliosis or initial scoliosis screening performed not in school but in other settings such as hospitals.

The titles and abstracts of all studies were assessed for the above eligibility criteria. If it was absolutely clear from the title and / or abstract that the study was not relevant, it was excluded. If it was unclear from the available abstract and / or the title, the full text article was retrieved.

Two reviewers assessed the content of the full text articles. Disagreements were resolved by discussion.

5.3. Quality assessment strategy

The methodological quality of all the relevant full text articles retrieved was assessed using the Critical Appraisal Skills Programme (CASP) tool depending on the type of study design.[13] Quality assessment was conducted by two reviewers. Disagreements were resolved by discussion.

All full text articles related to effectiveness were graded based on guidelines from the U.S./Canadian Preventive Services Task Force (Appendix 1)[14] and all full text articles related to diagnostic studies were graded according to the Hierarchy of evidence for test accuracy studies, CRD Report Number 4 (2nd Edition), March 2001(Appendix 2).[15]

5.4. Data extraction strategy

The following data were extracted:-

- ❖ Details of methods and study population characteristics
- ❖ Details of the intervention and comparator
- ❖ Details of individual outcomes for effectiveness, safety, cost-effectiveness and diagnostic accuracy of tests

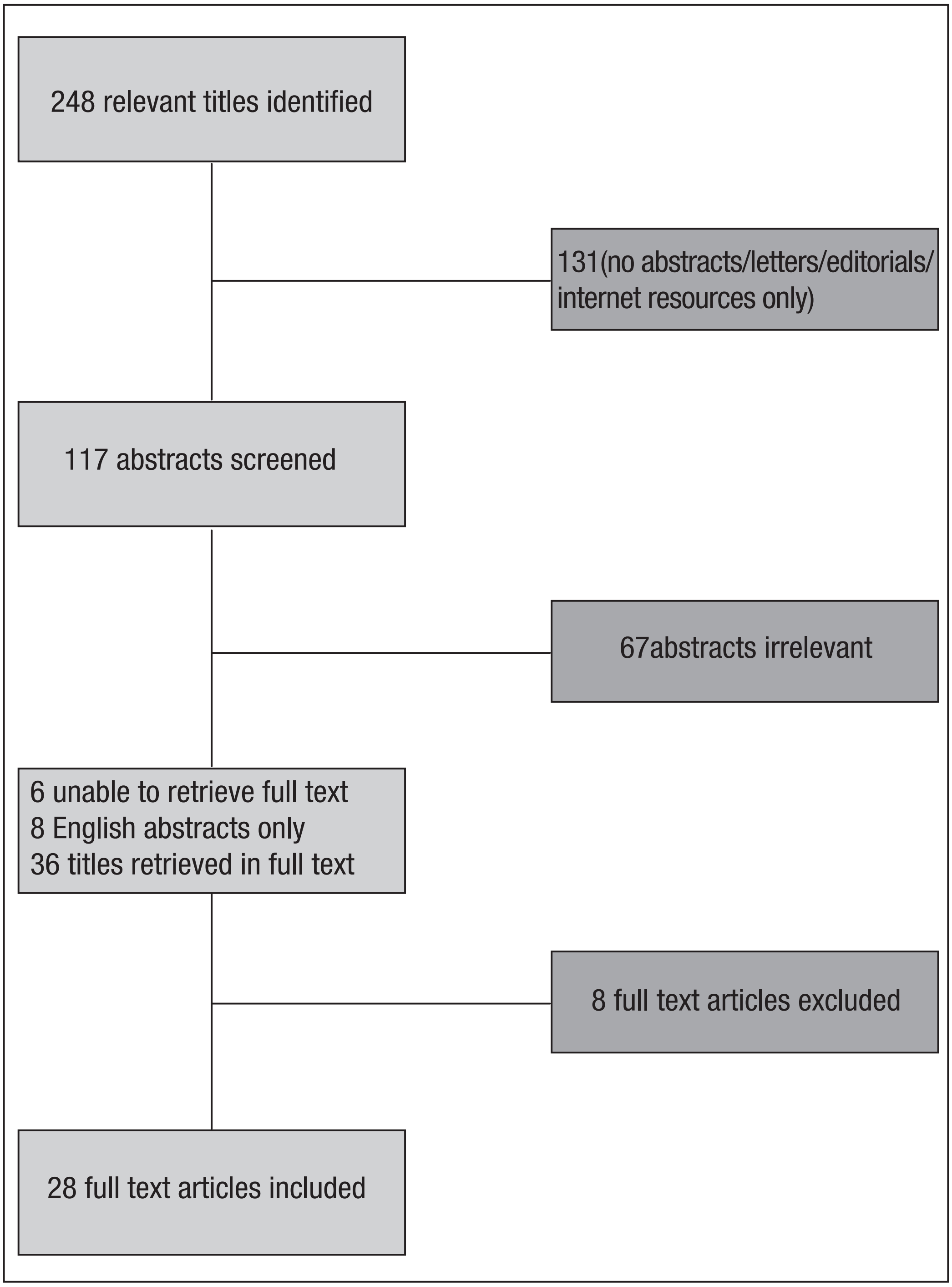
Data was extracted from included studies by a reviewer using a pre-designed data extraction form (evidence table as shown in Appendix 4) and checked by another reviewer. Disagreements were resolved by discussion. The extracted data were presented in evidence tables and discussed with the expert committee before deciding on the eligibility of articles to be included in this report.

6 RESULTS AND DISCUSSION

Search strategies yielded many published articles related to school scoliosis screening programme. A total of 248 relevant titles were identified and 117 abstracts were screened using the inclusion and exclusion criteria. Of these, 67 abstracts were found to be irrelevant. Thirty six potentially relevant articles were retrieved in full text and eight were in English abstracts only. Full-text for six abstracts could not be retrieved. After reading and appraising the full text articles, twenty-eight articles were included as shown in Figure 8. Eight full text articles were excluded based on inclusion and exclusion criteria and quality of the studies and are listed in Appendix 5.

The breakdowns of included studies are: 16 articles for effectiveness, six articles for economic evaluation (3 overlap with effectiveness), 7 articles on diagnostic accuracy of the screening tests and 2 articles on radiologic examination. The articles comprised of one case control study, one before and after study, 7 cross sectional diagnostic studies and 19 cross sectional studies. The search did not yield any health technology assessment reports, systematic reviews or RCT related to the effectiveness of school scoliosis screening programme.

Figure 8. Flow chart of retrieval of articles used in the results



6.1. EFFECTIVENESS

6.1.1 Detection of scoliosis among school children

Important information regarding the prevalence of scoliosis has been made available from school scoliosis screening programmes. Screening for scoliosis in schools and communities are practiced in parts of the United States of America, Japan, Netherlands, China, India, Greece, Australia, and Singapore. Generally, the overall prevalence of scoliosis among school children aged six to nineteen years with Cobb angle of 10° or more ranged from 1.00% to 2.50% as shown in Table 1. [16,17,18,19,20,21,22,24 level II-3]However, the overall prevalence of scoliosis was found to be lower among Singaporean school children aged six to fourteen years old; 0.59% as demonstrated by Wong *et al.*[16 level II-3] Studies done by Wong *et al.*, Yawn *et al.*, Morais *et al.*, Gore *et al.* and Pin *et al.* have demonstrated that the prevalence of scoliosis decreases with increases in Cobb angle whereby the overall prevalence of scoliosis with Cobb angle of 20° or more in these studies ranged from 0.14% to 1.00%. [16,17,19,20,24 level II-3]

Several studies have shown that the prevalence of scoliosis was higher in girls compared to boys.[16,20,23 level II-3] Wong *et al.* found that the prevalence of scoliosis was low in children aged six to seven and nine to ten years but increased rapidly to 1.37% and 2.22% for girls at 11 to 12 and 13 to 14 years of age, respectively.[16 level II-3] In another study, Gurr J.F. demonstrated that in children with curves greater than 21°, girls predominate by 5.4:1.0.[20 level II-3] Ohtsuka *et al.* found that girls to boys predominance of scoliosis cases with curvatures of more than 20° was 10:1 and was the same for primary school children and junior high school students.[25 level II-3]

Yawn *et al.* demonstrated that the number needed to screen to identify a child with a curve of least 20° by 19 years of age was 140 and to identify one child who subsequently needed treatment was 448.[17 level II-3] Generally the number needed to screen to identify a child with a Cobb angle of 10° or more ranged from 48 to 58 as shown in Table 1. However, the number needed to screen in order to identify a child with a Cobb angle of 10° or more was higher in the study conducted by Wong *et al.*,(169).[16 level II-3]The number needed to screen in order to identify one child who subsequently needed treatment ranged from 429 to 466 as shown in Table 1.

Table 1. Prevalence Rates and Number Needed to Screen (NNTS) by Sex and Cobb angle

Authors	Population	Cobb angle	Age group	Sex	Prevalence (%)	NNTS
Wong *et al.*	152,000	≥ 10°	6 to 14 years	F	0.93	
Singapore,				M	0.25	
2004				All	0.59	169
		≥ 20°		All	0.25	392
		≥ 30°		All	0.08	1160
						* (treatment)
Yawn *et al.*	2,242	≥ 10°	Grade 5 to 19	F	*	
Rochester,			years	M	*	
Minnesota,				All	1.80	55
1999		≥ 20°		All	1.00	140
		≥ 30°		All	*	*
		≥ 40°		All	0.40	*
						448(treatment)
Soucacos *et al.*	82,901	≥ 10°	9 to 14 years	F	*	
Greece, 1997				M	*	
				All	1.70	58
		≥ 20°		All	*	*
		≥ 30°		All	*	*
		≥ 40°		All	*	*
						458(treatment)
Morais *et al.*	29,195	≥ 10°	8 to 15 years	F	*	
Quebec, 1985				M	*	
				All	1.76	57
		≥ 20°		All	0.34	295
		≥ 30°		All	*	*
		≥ 40°		All	*	*
						429(treatment)
Gore *et al.*	8,393	≥ 10°	Fifth to tenth	F	2.00	
Winconsin			for girls and	M	1.70	
Country, 1981			seventh and	All	2.00	50
		≥ 20°	eighth for	F	0.50	
			boys	M	0.10	
				All	0.40	221
		≥ 30°		All	*	*
		≥ 40°		All	*	*
						466 (treatment)
Gurr JF.	26,947	≥ 10°	Grades seven	F	*	
Montreal, 1977			and eight	M	*	
				All	2.00	*
		≥ 20°		All	*	*
		≥ 30°		All	*	*
		≥ 40°		All	*	*
						* (treatment)
Dickson *et al.*	1,764	≥ 10°	13 to 14 years	F	*	
Oxford, 1980				M	*	
				All	2.50	*
		≥ 20°		All	*	*
		≥ 30°		All	*	*
		≥ 40°		All	*	*
						* (treatment)
Smyrnis *et al.*	3,494	≥ 10°	Sixth grade	F	4.60	
Oxford, 1980			(11 to 12	M	1.10	
			years)	All	*	*
		≥ 20°		All	*	*
		≥ 30°		All	*	*
		≥ 40°		All	*	*
						* (treatment)
Pin *et al.*	8,165	≥ 10°	6 to 15 years	F	*	
China, 1985				M	*	
				All	2.40	48
		≥ 20°		All	0.14	817
		≥ 30°		All	*	*
		≥ 40°		All	*	*
						* (treatment)

*Information not provided or examined during study

Few studies demonstrated the value of school scoliosis screening programmes in early detection of scoliosis. Bunge *et al.*, in his case control study involving 108 consecutive patients who were treated surgically for idiopathic scoliosis (cases) and 216 control subjects demonstrated that patients detected through screening had significantly smaller Cobb angles at diagnosis, compared to otherwise-detected patients with a mean of 34° ± 16.1° versus mean of 46° ± 13.3°, $p<0.01$. He also demonstrated that these patients were diagnosed at a significantly younger age than otherwise detected patients with a mean of 10.8 yrs ± 2.6 versus mean of 13.4 yrs ± 1.7. Patients detected through screening had an almost threefold greater chance of being treated with brace before surgery [(Odds Ratio (OR) = 3.1; 95% Confidence Interval (CI) =1.3 to 7.0)].[26 level II-2]

Similar findings were demonstrated by him in another cross sectional study involving 125 patients with adolescent idiopathic scoliosis who had completed treatment with a brace, surgery or with a brace followed by surgery. He demonstrated that patients detected through screening had significantly smaller Cobb angles at diagnosis, compared to otherwise-detected patients with a mean of 28° ± 12.6° versus mean of 40°± 15.7°, $p<0.01$. He also found that patients detected by screening were significantly younger at detection with a mean of 9.9 yrs ± 2.6 versus mean of 12.6 yrs ± 2.4, $p<0.01$. Patients detected through screening were also significantly younger at diagnosis than otherwise–detected patients, with a mean of 10.9 yrs ± 2.5 versus mean of 13.1 yrs ± 2.5, $p<0.01$.[27 level II-3]

Velezis *et al.* highlighted a problem faced by the scoliosis screening programme in schools in Columbia involving 52,300 school children whereby many of the referred cases were never followed-up and therefore led to the difficulty in knowing the true prevalence of scoliosis.[28 level II-3]

The benefits of having a complimentary screening session (CSS), on alternate years in addition to the biennial periodic health checks was investigated by Prujis *et al.* among school children aged 10 to 16 years in central part of Netherlands. He concluded that continuation of regular periodic checks biennially including quantification of trunk asymmetry among these age groups would enable all scoliosis over 19° Cobb angle to be detected.[29 level II-3]

6.1.2. Risk of progression

In a follow-up study involving 186 girls and 22 boys with scoliosis for a minimum of six months to 5.3 years, Gore *et al.* found that 141 (75.80%) girls and 20 (90.90%) boys had no change in the degree of curve. Twenty four (12.90%) girls and one (4.50%) boy had a decrease in their curve of at least 5° and 21 (11.30%) girls and one (4.50%) boy had an increase in their curve of at least 5°. He concluded that determination of which curves would progress was unpredictable and identification of progression was possible only by repeated examinations.[20 level II-3]

In another study, Smyrnis *et al.* followed-up 112 children, aged 11 to 12 years with curves of 7° to 12° for an average of 19 months. He found that the curves in girls showed greater tendency to progress as did larger curves in both sexes. About 77% of the right thoracic curves showed deterioration.[23 level II-3]

Pin *et al.* in a follow-up study among 304 children in China, aged 6 to 16 years, with scoliosis showed that only 47.90% remained unchanged, while 20.70% regressed, 8.50% improved, 18.40% altered and 4.90% deteriorated.[24 level II-3]

6.1.3. Impact of scoliosis screening on frequency of surgical treatment

There was inconsistency in the results of four studies. Three studies reported a reduction in surgery. In 1993, Montgomery and Wilner reported that the introduction of scoliosis screening programme in schools decreased the relative risk of progression into surgical range by a factor of eight. He obtained an eight times greater risk of deterioration to Cobb angle of 45° or more before screening period than after screening period (OR = 7.9, 99% CI = 1.6 to 36), without modifying the indications for treatment before and after the implementation of the screening programme.[30 level II-3]

Loenstin *et al.* studied the experience in Minnesota over eight years involving a quarter of a million school children screened yearly. He reported that the percentage of children requiring surgery has declined from 0.017% in 1974 to 0.004% in 1979. He also reported that the mean size of the major curve at the time of operation decreased from 60° in 1971 to 42° in 1979.[31 level II-3]

Bunge *et al.* in a cross sectional study involving 125 patients with adolescent idiopathic scoliosis who had completed treatment with a brace, surgery or with a brace followed by surgery reported that 45% of patients detected through screening needed surgery, compared to 75% of the otherwise-detected patients. The odds ratio (OR) for surgery for patients detected through screening was 0.27 (95% CI = 0.12 to 0.60). This means that patients who were detected by screening had a 73% lower chance of an adverse outcome (needing surgery).[27 level II-3]

However, one case control study conducted by Bunge *et al.* with the aim of testing the hypothesis that screening for scoliosis is effective in reducing the need for surgical treatment found that exposure to screening at the ages of 11, 12, 13 or 14 years did not reduce the chance of surgery significantly. The odds ratio (OR) for exposure to screening at the ages of 11, 12, 13 or 14 years and getting surgery was 0.64 (95% CI = 0.34 to 1.19, p = 0.16).[26 level II-2]

6.2. COST/ COST-EFECTIVENESS

There were no studies related to the Quality adjusted life year (QALY) gained. However, there were six studies on economic evaluation related to school scoliosis screening programmes. The cost of screening a child ranged from as low as US dollar (USD) 0.07, to as high as USD 43.7 as shown in Table 2, depending on how the cost was calculated.

Table 2. Estimated cost of finding one case of idiopathic scoliosis.

Authors	Cost per child / case	
Yawn *et al.* 2000, Rochester		**US dollar (USD)**
	Per child screened	$ 24.66
	Per child with Cobb angle ≥ 20°	$ 3,386.25
	Per child treated for scoliosis	$ 10,836.00
	- cost based on service charge and school cost - does not include indirect costs	
Morais *et al.* 1985, Quebec		**Canadian dollar (CAD)** (In 1997, 1 USD = 1.17 CAD)
	Per child screened	$ 2.31
	Per child referred for diagnostic evaluation including x-rays	$ 59.60
	Per case confirmed scoliosis	$ 194.27
	Per case brought to treatment	$ 3,508.49
	- direct costing only - does not include indirect costs	
Montgomery *et al.* 1990, Malmo,Sweden	Per child screened	**US dollar (USD)**
	No specific screening	$ 33.90
	Conventional clinical screening (Adams forward-bending test)	$ 43.70
	Combined clinical Moire Screening	$ 27.70
	- include health care costs and production lost	
Lonstein *et al.* 1982, Minnesota		**US dollar (USD)**
	Per child screened - include only salary of nurse coordinator	$ 0.07
	Per child screened - include only salary of nurse coordinator and school staff (time cost)	$ 0.35 (range from $0.24 to $1.75 depending on the size of the school and the salary scale of the screening staff)
Soucacos *et al.* 1997, Greece	Per child screened - cost based only on transportation	$ 0.30

Grivas *et al.* and Renshaw T.S. emphasised that cost of school screening should be the direct cost of the performance of the actual screening and not the subsequent expenditure of follow-up, radiographs and other modalities.[4,10]

Yawn *et al.* in his analysis based on service charges and school cost estimated the cost per child screened to be USD 24.66 and the for finding a child with Cobb angle 20° or more was USD 3,386.25. The estimated cost per child treated was USD 10,836.00.[32] Based on direct costing, Morais *et al.* estimated the cost for screening was CAD 2.31. The cost for diagnostic evaluation including x-rays was CAD 59.60, the cost of finding a case of confirmed scoliosis was CAD 194.27 and for treatment was CAD 3,508.49.[19] Lonstein *et al.* estimated that the cost per child screened based only on the salary of nurse coordinator was USD 0.07. However, the cost range from USD 0.24 to USD 1.75 if the salary of screening staffs were included depending on the size of the school and the salary scale of the screening staff.[31]

Montgomery *et al.* studied the cost-effectiveness of three different screening methods based on health care cost and production loss. He estimated that the total cost per screen was USD 33.90 for no specific screening, USD 43.70 for conventional clinical screening using Adams forward-bending test and USD 27.70 for combined clinical and Moire screening.[33]

Thilagaratnam S. conducted a cost-effectiveness analysis of school based screening programme and follow-up programme in Singapore with the alternative of not having the screening programme. His analysis was based on direct and indirect costs. The total cost to screen, follow-up and treat (bracing for 36 school children and surgery for 21 school children) in the screening programme was SGD 1,063,010.82.[34]

It was assumed that without a screening programme, all school children who had their curves braced (36 in total) would have had surgery in addition to the 21 school children who had surgery even with a screening programme. The total cost without the screening programme was SGD 1,358,104.80 was the sum of the direct costs of surgery and follow-up, and the indirect costs, comprising time costs for the parents accompanying the child for surgical admission and follow-up visits. Nett cost, which is the difference between the cost of the programme and the 'saving' in the absence of the programme, was minus SGD 295,093.98. A sensitivity analysis was performed by varying the numbers who would need surgery. Even if only about 65% of the 36 patients required surgery, the nett cost remains negative. He concluded that Singapore's school-based scoliosis screening programme which is implemented as part of the larger school screening and immunisation programme is cost-effective. Cost-effectiveness may be further improved by targeting screening at high risk groups, such as pre-pubertal females. [34]

6.3 DIAGNOSTIC ACCURACY OF SCREENING TESTS

It is evident that the value of any screening programme depends partly upon the accuracy of the screening tests. Few cross sectional diagnostic studies related to Adams forward-bending test, scoliometer, Moire topography and measurement of rib hump using humpometer were retrieved. All the studies had verification bias (not all patients were subjected to the screening test and the reference standard) with the exception of one study by Karachalios *et al.* This is to avoid inappropriate use of spine radiographs. Table 3 below shows the sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and area under receiver operating characteristic curve (AUC) of Adams forward-bending test, scoliometer, Moire topography and measurement of rib hump using humpometer.

Table 3. Diagnostic Accuracy of screening tests used in school scoliosis screening

Authors	Population	Screening test	Diagnostic accuracy
Adams forward- bending test			
Karachalious *et al.* 1999, Samos, Greece	2,700		Sensitivity - 0.84 Specificity - 0.93 PPV - 0.13 NPV - 0.99
Goldberg *et al.* 1995, Dublin, Ireland	8,686		Sensitivity - 0.83 Specificity - 0.98 PPV - 0.08
Lauland *et al.* 1982, Herning, Denmark	1,034		PPV - 0.10 NPV - 0.97
Scoliometer			
Karachalious *et al.* 1999, Samos, Greece	2,700	ATR > 0°	Sensitivity - 0.96 Specificity - 0.79 PPV - 0.05 NPV - 0.99
Huang *et al.* 1997, Taiwan	34,234	ATR ≥ 5°	PPV for scoliosis ≥ 10°- 0.28 PPV for scoliosis ≥ 20°- 0.04 PPV for scoliosis ≥ 30°- 0.008 PPV for scoliosis ≥ 30° - 0.004
Prujis *et al.* 1995, Netherland	3,069	ATR ≥ 5°	AUC - 0.56
Moire topography			
Karachalious *et al.* 1999, Samos, Greece	2,700		Sensitivity - 1.0 Specificity - 0.85 PPV - 0.07 NPV - 1.0
Lauland *et al.* 1982, Herning, Denmark	1,034	Asymetry of more than one contour line	PPV - 0.29 NPV - 0.99
Prujis *et al.* 1995, Netherland	3,069	Asymetry of two line or more	AUC - 0.59
Humpometer			
Karachalious *et al.* 1999, Samos, Greece	2,700	Hump ≥ 5 mm	Sensitivity - 0.93 Specificity - 0.78 PPV - 0.04 NPV - 0.99
Prujis *et al.* 1995, Netherland	3,069	Rib hump height of ≥ 8 mm in thoracic or thoracolumbar region or ≥ 5 mm in lumbar	AUC - 0.58

Adams forward-bending test had a lower sensitivity (0.84) but a higher specificity (0.93) compared to scoliometer, Moire topography and humpometer as demonstrated by Karachalios *et al.*[8 level].[2] Since the prevalence rate of scoliosis is low, the PPV was low for all the tests. The PPV was 0.13 for Adams forward-bending test, 0.05 for scoliometer, 0.07 for Moire topography and 0.04 for humpometer. All the tests have high NPV ranging from 0.99 to 1.00. Adams forward-bending test resulted in a number of false negatives.

Time spent for Moire topography was 40 seconds per person, scoliometer was 20 seconds per person, humpometer was 1 minute per person and Adams forward-bending test was 30 seconds per person.[8 level 2]

Goldberg *et al.* reported that the sensitivity of Adams forward-bending test was 0.83, specificity was 0.98 and PPV was 0.08.[35 level 3]

Huang *et al.* showed that at ATR of 5° or more, the PPV of the scoliometer varied depending on the Cobb angle. He concluded that the cut-off point for referral when using the scoliometer in school screening of scoliosis is still difficult to determine.[36 level 3]

Prujis *et al.* demonstrated that there was no significant difference in the ability to detect scoliosis between scoliometer, humpometer and Moire topography. The AUC was 0.56 for scoliometer, 0.59 for Moire topography and 0.58 for humpometer. [4 level 3]

In another study, Lauland *et al.* demonstrated that Moire topography detected 39 out of 41 confirmed scoliosis cases while clinical screening including Adams forward-bending test revealed only 19 out of 41 scoliosis. The weakness of Moiré topography was the large number of false positive results. The PPV for Moire was 0.29 compared to 0.18 for the Adams forward-bending test. [37 level 2]

Daruwalla J.S. and Balasubramaniam P. showed that the accuracy of Moire topography in identifying the site of the curve was 68.00% in the thoracic spine, 54.00% in the thoracolumbar spine, and 15,00% in the lumbar region. There were 12.70% false-positive results and 4.30% false negatives. He suggested that moiré topography as a screening device should be reserved for use in the second tier of screening, since the Adams forward-bending test is an effective and cheap method for the first tier of mass school scoliosis screening programmes.[38 level 2]

Grossman *et al.* compared the use of Adams forward-bending test and scoliometer to detect truncal rotation or asymmetry in a school screening programme involving 954 school children. He found that by using ATR of 5° or more, 123 (13.00%) of school children with normal visual examinations (Adams forward-bending test) were found to be abnormal when tested using scoliometer. When ATR of 7°or more was used, 13 (1.40%) with normal visual examination were found to be abnormal when tested using scoliometer. He highlighted that selecting patients for scoliometer examinations based on Adams forward-bending test may increase the risk of false-negative examinations. He advocated the use of scoliometer to screen all children and not just those who appear positive on the Adams forward-bending test.[39 level 3]

6.4 OTHER CONSIDERATIONS

6.4.1. Safety

There have been concerns with regards to over-referrals and the effect of radiation exposure to adolescents during follow-up. Yawn *et al.* in his retrospective cross-sectional study among 2,242 children in Rochester, Minnesota noted that school screening identified five out of nine children treated for scoliosis but resulted in referrals for another 87 children who were not treated.[17 level II-3]

Chamberlain *et al.* in his cross sectional study of 61 consecutive patients undergoing scoliosis radiography showed that patients undergoing scoliosis radiography receive effective doses that are low in comparison with other types of radiographic examination.[40] In another study, Manninen *et al.* demonstrated that the use of photofluorographs results in a radiation dose reduction of about one-half and leads to considerable savings in direct imaging costs as well as conserves space. It is particularly suited for follow-up and screening evaluation of scoliosis, but in tall patients the image field size of 40 cm x 40 cm restricts its usefulness as an initial examination method.[41] Karachalios *et al.* showed that during his screening program, it would have been possible to reduce radiologic examination by 89.40% if cut off limits for referral had been used such as asymmetry of two Moire fringes, a humpogram deformity = 10mm, and 8°of scoliometer angle.[8 level II-2]

6.4.2. Organisational

In many studies, scoliosis screening took place during physical education classes and was conducted by school health nurses or medical officers. Boys and the girls were examined separately. Boys wore shorts and the girls wore shorts and brassiere or a loose T-shirt that could be lifted during the examination.[16,17,18 level II-3] Soucacos *et al.* highlighted the fact that extreme caution with regard to the feelings of the children was of paramount importance to the success of the programme. For example, the child might be embarrassed to show physical scar or a garment which the child believed was “too poor”.[18 level II-3]

Training of scoliosis screening teams in screening methods is one of the prerequisite before the programme is implemented. Children who were found to be positive during screening need to be referred to referral clinics for further examination and follow-up.[16,17,18.19 level II-3]

6.4.3. Legal

In the U.S., as of 2003, 21 States had legislated school screening; 11 States recommended school screening without legislation and the remaining either had voluntary screenings or recommended not to conduct screening in the schools. Japan has federally mandated school scoliosis screening programme, mostly accomplished with surface topography using moiré technique and low-dose roentgenographic techniques.[5]

7 CONCLUSION

7.1. Effectiveness

Girls generally achieve adolescence two years before boys and are afflicted with scoliosis three to four times more frequently than boys. This statement is supported by the following findings:-

i. Prevalence of scoliosis was higher in girls compared to boys. [Wong *et al.*, Gore *et al.*, Symrnis *et al.*]

ii. Prevalence in girls was low for those six to ten years of age but increased rapidly from eleven to fourteen years of age. [Wong *et al.*]

There was fair level of evidence to suggest that school scoliosis screening programme was able to:-

i. Detect scoliosis at a younger age and with smaller Cobb angle

ii. Reduce the frequency of surgical treatment

7.2. Cost /Cost-effectiveness

i. The cost of screening a child ranged from USD 0.07 to USD 43.70 depending on how the cost was calculated

ii. There was evidence to suggest that school-based scoliosis screening programme was cost-effective

7.3. Diagnostic accuracy of screening tests

i. There was fair level of evidence to suggest that Adams forward-bending test, measurement of angle of trunk rotation using scoliometer, measurement of rib hump height using humpometer and Moire topography can be used as a screening test for scoliosis screening in schools and is not time consuming.

However, the use of Adams forward-bending test may result in high false negatives which may lead to miss-diagnosis while the use of other screening tests such as scoliometer, Moire topography and humpometer may lead to high false positives and will cause over-referrals. Few studies have suggested that the use of cut off limits for referrals such as asymmetry of two Moire fringes, a humpogram deformity = 10 mm, and 7° or 8° of scoliometer angle would lead to a reduction in the number of referral for radiographic examination.

7.4. Other considerations

i. Evidence suggests that radiographic examination for scoliosis follow-up was safe

ii. Proper training of staff involved in the screening programme is necessary together with a good referral and follow-up system based on ethical and organisational consideration.

8 RECOMMENDATION

i. Based on the above review, screening for scoliosis among school children is recommended only for high risk group such as girls at twelve years of age (standard six).

ii. A combination of modalities of screening tests such as Adams forward-bending test and scoliometer with ATR of 7° is recommended with the aim of reducing the number of referrals.

iii. However, organisational issues such as training, manpower, good referral system, treatment and funding need to be addressed at all levels.

REFERENCES

9 REFERENCES

1. Reamy BV and Slakey JB. Adolescent idiopathic scoliosis: review and current concepts. American Family Physician.2001; 64(1): 111-116
2. McCarthy RE. Prevention of the complications of scoliosis by early detection. Clinical Orthopaedics and Related Research.1987;222: 73-78
3. Richards BS and Vitale MG. The orthopaedic forum; Screening for idiopathic scoliosis in adolescents: An Information Statement. The Journal of Bone and Joint Surgery Am . 2008; 90-A(1): 195-198
4. Prujis JEH, Keesen W, van der Meer R *et al.* School screening for scoliosis: the value of quantitative measurement. Eur Spine J.1995; 4: 226-230
5. Grivas TB, Wade MH, Negrini S *et al.* SOSORT concensus paper: school screening for scoliosis. Where are we today?. Scoliosis.2007; 2(17). Available at http://www.scoliosisjournal.com/content/2/1/17
6. Chuah SI, Kareem BA, Selvakumar K *et al.* The natural history of scoliosis: curve progression of untreated curves of different aetiology, with early (mean 2 year) follow up in surgically treated curves. Med J Malaysia. 2001; 56 Supplement C: 37-40
7. Azlin A. Screening for scoliosis among students age 11 to 15 years old in Kuala Terengganu, Terengganu. Thesis submitted in partial fulfilment for the degree of masters of medicine (family medicine).2005
8. Karachalios T, Sofianos J, Roidis N *et al.* Ten-year follow-up evaluation of a school screening program for scoliosis. Is the forward-bending test an accurate diagnostic criterion for screening of scoliosis?.SPINE.1999; 24(22):2318-2324
9. Renshaw RS. Screening school children for scoliosis. Clinical Orthopaedics and Related Research.1988; 229:26-33
10. Stig Willner. Moire topography- A method for school screening of scoliosis*. Archieves of Orthopaedic and Trauma Surgery.1979;95:181-185
11. Greiner KA. Adolescent idiopathic scoliosis: radiologic decision-making. American Family Physician.2002;65(9):1817-1822
12. Rowe DE, Bernstein SM, Riddick MF *et al.* A meta-analysis of the efficacy of non-operative treatments for idiopathic scoliosis. The Journal of Bone and Joint Surgery.1997; 79-A (5): 664-672
13. Critical Appraisal Skills Programme (CASP 2004). CASP available at http://www.phru.nhs.uk/Pages/PHD/CASP.htm
14. Harris RP, Helfand M, Woolf SH *et al.* Current Methods of the U.S. Preventive Services Task Force: A review of the Process. Am J Prev Med. 2001; 20 (suppl 3):21-35

15 Khan KS, Gerben ter Riet, Glanville J *et al.* Undertaking systematic reviews of research on effectiveness. CRD's Guidance for those carrying out or commissioning reviews. CRD Report Number 4 (2nd Edition) May 2001. Available at http://www.york.ac.uk/inst/crd/report4.htm

16 Wong HK, Hui JHP, Rajan U *et al.* Idiopathic Scoliosis in Singapore Schoolchildren. A prevalence study 15 years into the screening program. SPINE.2005; 30(10):1188-1196

17 Yawn BP, Yawn RA, Hodge D *et al.* A population based study of school scoliosis screening. JAMA. 1999; 282(15):1427-1432

18 Soucacos PN, Soucacos PK, Zacharis KC *et al.* School-screening for scoliosis. A prospective epidemiological study in Northwestern and Central Greece. The Journal of Bone and Joint Surgery. 1997; 79-A (10):1498- 1503

19 Morais T, Bernier M, Turcotte F. Age-and sex-specific prevalence of scoliosis and the value of school screening programs. AJPH. 1985; 75(12):1377-1280

20 Gore DR, Passehl R, Sepic S *et al.* Scoliosis screening. Results of a community project. PAEDIATRICS. 1981; 67(2):196-200

21 Gurr JF. A school screening program that works. The Canadian Nurse. 1977; 73(12):24-29.

22 Dickon RA, Stamper P, Sharp A *et al.* School screening for scoliosis: cohort study of clinical course. British Medical Journal. 1980; July: 265-267.

23 Smyrnis PN, Valavanis J, Alexopoulos A *et al.* School screening for scoliosis in Athens. The Journal of Bone and Joint Surgery. 1979; 61-B (2):215-217.

24 Pin LH, Mo LY, Lin L *et al.* Early diagnosis of scoliosis based on school-screening. The Journal of Bone and Joint Surgery.1985; 67-A(8):1202-1205

25 Ohtsuka Y, Yamagata M, Arai S *et al.* School Scoliosis screening for scoliosis by the Chiba University Medical School Screening Program. Results of 1.24 million students over an 8-year period. SPINE. 1988; 13(11):1251-1257

26 Bunge EM, Juttmann RE, van Biezen FC *et al.* Estimating the effectiveness of screening for scoliosis: A case- control study. PEDIATRICS. 2008;121(1): 9-14

27 Bunge EM, Juttmann RE, de Koning HJ *et al.* Screening for scoliosis: do we have indications for effectiveness?. Journal of Medical Screening. 2006;13 (1): 29-33

28 Velezis MJ, Sturm PF, Cobey J. Scoliosis screening revisited: Findings from the District of Columbia. Journal of Paediatric Orthopaedics. 2002; 22: 788-791.

29 Prujis JEH, van der Meer, Hageman MAPE *et al.* The benefits of school screening for scoliosis in the central part of the Netherlands. Eur Spine J. 1996; 5: 374-379

30 Montgomery F, Wilner S. Screening for idiopathic scoliosis. Comparison of 90 cases shows less surgery by early diagnosis. Acta Orthop Scand. 1993; 64(4): 456-458

31 Lonstein JE, Bjorklund S, Wanninger MH. Voluntary school screening for scoliosis in Minnesota. The Journal of Bone and Joint Surgery.1982; 64-A (4): 481-488

32 Yawn BP, Yawn RA. The estimated cost of school scoliosis screening. SPINE.2000; 25(18): 2387-2391

33 Montgomery F, Persson U, Benoni G *et al.* Screening for scoliosis. A cost-effectiveness analysis. SPINE. 1990; 15(2): 67-70

34 Thilagaratnam S. School-based screening for scoliosis: is it cost-effective? Singapore Med J. 2007; 48(11):1012

35 Goldberg CJ, Dowling FE, Fogarty EE *et al.* School scoliosis screening and the United States Preventive Services Task Force. An examination of long term results. SPINE.1995; 20(12):1368-1374

36 Huang SC. Cut- off point of the scoliometer in school scoliosis screening. SPINE. 1997; 22(17):1985-1989

37 Laulund T, Sojbjerg JO, Horlyck. Moire topography in school screening for structural scoliosis. Acta orthop scand. 1982;53:765-768

38 Daruwalla JS, Balasubramaniam P. Moire topography in scoliosis. The Journal of Bone and Joint Surgery. 1985; 67-B (2):211-213

39 Grossman TW, Mazur JM, Cummings RJ. An evaluation of the Adams forward-bending test and the scoliometer in scoliosis school screening setting. Journal of Pediatric Orthopaedics.1995; 15(4):535-538.

40 Chamberlain CC, Huda W, Hojnowski LS *et al.* Radiation doses to patients undergoing scoliosis radiography. The British Journal of Radiology. 2000; 73: 847-853

41 Manninen H, Kiekara O, Soimakallio S *et al.* Reduction of radiation dose and imaging costs in scoliosis radiography. Application of large-screen image intensifier photofluorography. SPINE. 1988; 13 (4):409-412

APPENDIXES

APPENDIX 1

HIERACHY OF EVIDENCE FOR EFFECTIVENESS STUDIES

LEVEL	DESIGNATION OF EVIDENCE
I	Evidence obtained from at least one properly designed randomized controlled trial.
II-I	Evidence obtained from well-designed controlled trials without randomization.
II-2	Evidence obtained from well-designed cohort or case-control analytic studies, preferably from more than one centre or research group.
II-3	Evidence obtained from multiple time series with or without the intervention. Dramatic results in uncontrolled experiments (such as the results of the introduction of penicillin treatment in the 1940s) could also be regarded as this type of evidence.
III	Opinions or respected authorities, based on clinical experience; descriptive studies and case reports; or reports of expert committees.

SOURCE: US/Canadian Preventive Services Task Force (Harris 2001)

APPENDIX 2

HIERACHY OF EVIDENCE FOR TEST ACCURACY STUDIES

LEVEL	DESCRIPTION	
1.	A blind comparison with reference standard among an appropriate sample of consecutive patients	
2.	Any one of the following	Narrow population spectrum
3.	Any two of the following	Differential use of reference standard
4.	Any three or more of the following	Reference standard not blind Case control study
5.	Expert opinion with no explicit critical appraisal, based on physiology, bench research or first principles.	

SOURCE: NHS Centre for Reviews and Dissemination (CRD) University of York, Report Number 4 (2nd Edition)

APPENDIX 3

PTK-FM-02

HEALTH TECHNOLOGY ASSESSMENT (HTA) PROTOCOL EFFECTIVENESS AND COST-EFFECTIVENESS OF SCHOOL HEALTH SCOLIOSIS SCREENING PROGRAMME

1 BACKGROUND INFORMATION

The Scoliosis Research Society has defined scoliosis as a lateral curvature of the spine greater than 10 degrees as measured using the Cobb method on a standing radiograph. Idiopathic scoliosis is the most common forms of lateral deviation of the spine. Idiopathic scoliosis is a structural curve with no clear underlying cause. It usually becomes evident in the early adolescent years and although significant progress has been made in the genetic study of this disorder, its cause presently remains unknown, thus the label "idiopathic" scoliosis. Curve progression is unpredictable, though a subset of children with adolescent idiopathic scoliosis may exhibit rapid progression.

The prevalence of adolescent idiopathic scoliosis (AIS) when defined as a curvature greater than 10 degrees according to Cobb, is 2-3%. The prevalence of curvature greater than 20 degrees is between 0.3 to 0.5%, while the curvatures greater than 40 degrees Cobb is found in less than 0.1% of the population. The ratio of girls to boys with small curves of 10 degrees is equal but increases to a ratio of 10 girls for every one boy with curves greater than 30 degrees. Scoliosis in girls tends to progress more often and, therefore girls more commonly need treatment than boys. Once the diagnosis of scoliosis have been made, the primary concerns are whether there is an underlying cause and if the curvature will progress. The three main determinants of progression are patient gender, future growth potential and the curve magnitude at the time of diagnosis. Secondary causes of scoliosis can usually be identified by radiography and clinical examination.

Every year, thousands of operations are performed for the primary diagnosis of adolescent idiopathic scoliosis in patients between the ages of 10 to 18. The spinal disorder can have a significant impact on the physical and phychosocial health of affected individuals. Screening is the presumptive identification of unrecognized disease or defect by the application of tests, examinations, or other procedures that can be applied rapidly. The goal for screening is to detect scoliosis at an early stage when a deformity is likely to go unnoticed and when there is opportunity for a less invasive method of treatment than those otherwise be the case.

Screening for scoliosis was common in schools and communities in the past years such as in the United States, Japan, Netherlands, China, India, Greece, Australia, Canada and Singapore. All screening techniques depend on surface topography. Although there is no ideal screening test, Adams forward-bending test requires no additional equipment (such as scoliometer or humpometer) and can help identify scoliosis. The application of physical measurements provides a quantitative evaluation of deformity and the basis for objective referral criteria for screening. Many devices and techniques have been used, including measurement of rib hump height using a level and a ruler, stereophotogrammetry, flexicurve, ultrasound, thermography, Moiré topography, inclinometry, and scoliometer. None of these techniques is diagnostic. Radiographs are required to establish the diagnosis, aetiology and severity of spinal deformity.

At present scoliosis screening is not part of Malaysian School Health Service. In relation to this, cases of scoliosis were detected late when it became symptomatic and these conditions require corrective surgical procedures. A study conducted in Scoliosis Service of Hospital Kuala Lumpur by Chuah *et al.* among 152 patients demonstrated that median rate of curve progression of idiopathic scoliosis curves was 7.03 degrees per year and the mean preoperative curve size was 71.61 degrees.

2 POLICY QUESTION

Should scoliosis screening among school children be part of Malaysian School Health Programme?

3 OBJECTIVE /AIM

i. To undertake a systematic review on the effectiveness and cost-effectiveness of scoliosis screening among school children

ii. To assess the diagnostic accuracy of screening tests used in scoliosis screening among school children and to recommend the best screening tools (tests)

iii. To look into the safety aspect of radiography, the social, ethical and legal aspect related to scoliosis screening among school children

4 METHODOLOGY

4.1. Search strategy

Electronic database will be searched for published literatures pertaining to school scoliosis screening. The following sources will be searched:-

i. Databases as follows MEDLINE, PubMed, EBM Reviews – Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, HTA Database, EBM Reviews - NHS Economic Evaluation Database, EBM Full Text –Cochrane DSR, ACP Journal Club and DARE.

ii. Google was used to search for additional web-based information.

iii. Additional articles will be identified from reviewing the bibliographies of retrieved articles.

There will be no limitation in the search. The following search terms will be used either singly or in combination: school scoliosis screening, scoliosis screen*, School Health, Screening Program, scoliosis, and scoliometer.

4.2. Inclusion and exclusion criteria

Inclusion criteria

i.	Study design	:	Cross sectional, cohort, case control, Randomised Controlled Trial and systematic review
ii.	Population	:	School children
iii.	Interventions	:	Scoliosis screening using Adams forward-bending test and/or measurement of rib hump height using a level and a ruler, stereophotogrammetry, flexicurve, ultrasound, Moiré topography, inclinometry, and scoliometer.
v.	Comparators	:	No screening
vi.	Outcomes	:	*Primary outcome:-* The final outcome measure depends on the literature retrieved but is likely to include cost per quality adjusted life year (QALY) gained. *Secondary outcome:-* Detection rate, frequency of idiopathic scoliosis surgery, change of signs and symptoms of scoliosis after conservative treatment, rate of progression of idiopathic scoliosis after bracing, cost of performing screening program, Number Needed to screen, safety and diagnostic accuracy of different screening test used in school scoliosis screening

Exclusion criteria

Adult scoliosis, initial scoliosis screening performed in hospital setting (not performed in school)

Based on these inclusion criteria, study selection will be carried out independently by two reviewers. Disagreements will be resolved by discussion.

4.3. Data extraction strategy

The following data will be extracted:

- Details of methods and study population characteristics
- Details of the intervention and comparator
- Details of individual outcomes for effectiveness, safety, cost-effectiveness and diagnostic accuracy

Data will be extracted from included studies by a reviewer using a pre-designed data extraction form and checked by another reviewer. Disagreements will be resolved by discussion.

4.4. Quality assessment strategy

The methodological quality of all the relevant articles retrieved will be assessed using Critical Appraisal Skills Programme (CASP) depending on the type of study design. Quality assessment will be conducted by 2 reviewers

4.5. Methods of analysis / synthesis

Data on clinical effectiveness, safety, cost-effectiveness and diagnostic accuracy will be presented in tabulated format with narrative summaries. A decision on whether to pool efficacy, safety and accuracy outcomes will be taken following the updated search and based on clinical and statistical heterogeneity and the range of outcome measures reported. Data will be pooled using fixed effect model unless statistical heterogeneity between studies is found, in which case random effect model will be used.

5. Report writing

APPENDIX 4

Evidence Table : Effectiveness
Question1 : Is school scoliosis screening effective in detecting scoliosis ?
No. 1

Bibliographic Citation	Wong HK, Hui JHP, Rajan U *et al.* Idiopathic Scoliosis in Singapore Schoolchildren. A prevalence study 15 years into the screening program. SPINE.2005; 30(10):1188-1196
Study Type / Methodology	Prospective cross sectional study. (Period of 1 year in 1997). A total of 72,699 children aged 6 to 14 years, representing 50.7% of the total annual enrolment of 152,000 schoolchildren were screened for scoliosis. The schools were randomly selected for each group out of a total pool of 191 primary schools and 142 secondary schools. Four aged groups were screened. Initial screening was done in schools by State Registered Nurses. Forward-bending test performed. Children with scoliometer reading 5° or more were referred to the School Health Service. Questionnaires, physical examination and scoliometer readings were performed. Those with scoliometer reading more than 5° underwent radiographic examination. Prevalence rate calculated at predefined Cobb angles of 5°, 10°, 20° and 30°.
LE	II-3
Number of patients and patient characteristics	A total of 35,558 boys and 37,141 girls were screened. 4 age groups were screened. 6 - 7 years (primary one or first grade) 9 - 10 years (primary four or fourth grade) 11 - 12 years (primary six or sixth grade) 13 - 14 years (secondary two or eighth grade)
Intervention	Scoliosis screening in the schools using forward-bending test, scoliometer and radiographic evaluation
Comparison	
Length of follow up	
Outcome measures / Effect size	Out of 72,699 children screened 759 children were referred from school on the basis of positive scoliometer reading. (5° or more). Seven hundred and twenty nine attended clinic and were examined. 522 children with idiopathic scoliosis with curves greater than 5° or greater. Overall prevalence rate of scoliosis of schoolchildren 6 to 14 years of aged with Cobb angle of 10° or more was 0.59% (0.93% in girls and 0.25% in boys). Cobb angle ≥ 10°, prevalence rate were 0.05% for girls and 0.02% for boys at 6 to 7 years, 0.24% for girls and 0.15% for boys at 9 to 10 years of age, 1.37% for girls and 0.21% for boys at 11 to 12 years of age, 2.22% for girls and 0.66% for boys at 13 to 14 years of age. The overall prevalence rate of scoliosis with Cobb angle ≥ 20° was 0.25. The prevalence rate for girls 0.02% at 6 to 7 years, 0.05% at 9 to 10 years of age, 0.58 at 11 to 12 years and 1.25% at 13 to 14 years. The overall prevalence rate of scoliosis with Cobb angle ≥ 30°. The prevalence rate for girls 0.00% at 6 to 7 years, 0.01% at 9 to 10 years of age, 0.21 at 11 to 12 years and 0.52% at 13 to 14 years. Thoracolumbar curves were most common (40.1%), followed by thoracic curve (33.3%), double/ triple curves (18.7%) and lumbar curves (7.9%). The prevalence rate at predefined Cobb angle of 10° or more for 11 to 12 year old girls increased significantly from 0.83% in 1982 to 1.37% in 1997. Number needed to screen to identify one child with Cobb angle Cobb ≥ 10° was 149 (152,000/898), Cobb ≥ 20°was 392 (152,000/388) and Cobb ≥ 30° was 1,160 (152,000/131) Conclusion Screening of 11 to 12 and 13 to 14 year old girls identified a significant number who would benefit from brace treatment.
General Comments	

Evidence Table : **Effectiveness**
Question No.2 : **Is school scoliosis screening effective in detecting scoliosis ?**

Bibliographic Citation	Yawn BP, Yawn RA, Hodge D *et al.* A population based study of school scoliosis screening. JAMA. 1999; 282(15):1427-1432
Study Type / Methodology	Retrospective cross sectional study. All children attending public and private schools in Rochester who entered kindergarten in 1979, kindergarten or first grade in 1980-1981, or first grade in 1982 and who remained in the Rochester schools for at least 3 of the yearly school scoliosis screening test s beginning in grade 5, first year of screening (1984-1985) were included in the cohort. Children were followed up to age 19 years or until they left school district. Latest follow-up 1994. The results of scoliosis screening for each child in the cohort were abstracted from health records. All medical records of each child whose parents were sent referral or watch letters were identified using the record linkage system of Rochester Epidemiology project which indexes the care provided by all local medical facilities for all residents of Rochester and Olmsted Country.
LE	II-3
Number of patients and patient characteristics	2,242 school children grade 5 to 19 years.
Intervention	Scoliosis screening in the schools using forward-bending test, and scoliometer and spine x-rays
Comparison	
Length of follow up	Follow-up to age 19 years or until they left the school district.
Outcome measures / Effect size	Of the 2,242 children screened, 92 (4.1%) were referred for further evaluation. Of these 68 (74%) had documented medical or chiropractor evaluations of scoliosis. School screening identified 5 of the 9 children treated for scoliosis but resulted in referrals for another 87 children who were not treated. The cumulative incidence of diagnosed scoliosis was 1.8% for curves of more than 10°, 1.0% for curves of at least 20°, and 0.4% for curves of 40° or more.) . Zero point four percent (0.5% of girls and o.3% of boys) were treated for scoliosis. The Positive Predictive Value (PPV) of the school screening program for identification of treated scoliosis was 0.05 (95% CI=0.048 to 0.052) with 448 (2242/5) children needed to screen to identify 1 child who subsequently received treatment. To identify a child with a curve of at least 10° by 19 years of age, the number needed to screen was 55 (2242/41). To identify a child with a curve of at least 20° by 19 years of age, the number needed to screen was 140 (2242/16).
General Comments	

Evidence Table : **Effectiveness**
Question : Is school scoliosis screening effective in detecting scoliosis ?
No.3

Bibliographic Citation	Soucacos PN, Soucacos PK, Zacharis KC *et al.* School-screening for scoliosis. A prospective epidemiological study in Northwestern and Central Greece. The Journal of Bone and Joint Surgery. 1997; 79-A(10):1498- 1503
Study Type / Methodology	Prospective cross sectional study. (Period of 2 year between January 1993 and December 1994). A total of 82,901 children who were nine to fourteen years old were screened for scoliosis. Scoliosis screening teams consisting of a senior orthopaedic surgeon and staff member, an orthopaedic resident, a nurse and a medical student. Screening took place during Physical Education class. Physical examination and forward-bending test performed. If have at least one positive finding for scoliosis, which include asymmetrical shoulder levels, scapular prominence, unequal distance from the upper extremities to the flanks or inequality of the lengths of the lower limbs while child was standing, and a lateral deviation of the spine during the forward-bending test the child is re-examined to confirm criteria for referral. Rescreening A second forward-bending test performed and considered positive (a difference of more than five mm between the two sides of the torso as measured by in the thoracic or thoracolumbar region with use of a ruler and a level plane). The child was referred for radiographic evaluation. A curve with a Cobb angle of 10° or more was defined as having structural scoliosis.
LE	II-3
Number of patients and patient characteristics	A total of 82,901 children, (41,939 boys and 40,962 girls) nine to fourteen years old.
Intervention	Scoliosis screening in the schools using forward-bending test, level plane and ruler and radiographic evaluation
Comparison	
Length of follow up	
Outcome measures / Effect size	5,803 had clinical signs of scoliosis and of these 4,185 were referred for posteroanterior radiographs. Prevalence of scoliosis defined as Cobb angle 10° or more was 1.7% (1,436 of 82,901 children). Most of the curves (1255 were small 10° to 19°). Ratio of boys to girls was 1:1.2. overall but varied according to the magnitude of the curve (1: 1.5 for curves less than 10°, 1:2.7 for curves of 10° to 19, 1:7.5 for curves 20° to 29, 1:5.5 for curves of 30° to 39° and 1:1.2 for curves 40° or more. Thorocolumbar curves were most commonly identified followed by lumbar curves. Identified 11 children treated operatively and 170 children treated with brace. Number needed to screen to identify one child with Cobb angle of ≥ 10° was 58 (82,901/1,436) and number needed to screen to identify one child who subsequently received treatment was 458 (82,901/181).
General Comments	

Evidence Table : Effectiveness
Question : Is school scoliosis screening effective in detecting scoliosis ?
No. 4

Bibliographic Citation	Morais T, Bernier M, Turcotte F. Age-and sex-specific prevalence of scoliosis and the value of school screening programs. AJPH. 1985; 75(12):1377-1280
Study Type / Methodology	Cross sectional study. (Period from 1977 to 1978 in Quebec). A total of 29,195 children aged 8 to 15 years were screened for idiopathic scoliosis. Screening was performed in the schools, each child being examined by two specially trained nurses. Clinical inspection of the symmetry of the back using the forward-bending test performed. Unequal rib prominence or unilateral lumbar protrusion on bending forward was defined as positive sign for scoliosis. A screening record was completed for each child with a positive test. Each referred child was first to undergo clinical examination by an orthopaedic surgeon, followed by an x-ray of the spine when deemed necessary. Any curve of 5° or more, as measured by the Cobb method was reported as a case of scoliosis.
LE	II-3
Number of patients and patient characteristics	29,195 children aged 8 to 15 years-14,689 (50.3%) girls and 14,506 (49.7%) boys
Intervention	Scoliosis screening in schools using forward-bending test and x-ray of the spine
Comparison	
Length of follow up	
Outcome measures / Effect size	Screening test positive in 3,336 children and 1,868 (86%) was examined by orthopaedic surgeon. Idiopathic scoliosis was confirmed in 1227 (42.8%) of these 2,868 children. Prevalence of scoliosis (Cobb angle ≥ 5°) among school children aged 8 to 15 years is 42.0 per 1000. It is higher in girls (51.9/1000) than among boys (32.1/1000). Prevalence of scoliosis (Cobb angle ≥ 10°) among school children aged 8 to 15 years is 17.6 per 1000 or 1.76% and Cobb angle ≥ 20° was 3.4 per 1000 or 0.34%. Immediate treatment was recommended for 68 children (intermittent traction 36, braces 25 and surgery 7). Number needed to screen to identify one child with Cobb angle of ≥ 5° was 24, with Cobb angle of ≥ 10° was 57 (29195/513) and with angle of ≥ 20° was 295 (29195/99). Number needed to screen to identify one child who subsequently received treatment was 429.
General Comments	

Evidence Table : **Effectiveness**
Question : **Is school scoliosis screening effective in detecting scoliosis ?**
No. 5

Bibliographic Citation	Gore DR, Passehl R, Sepic S *et al.* Scoliosis screening. Results of a community project. PAEDIATRICS. 1981; 67(2):196-200
Study Type / Methodology	Cross sectional study. (Period from 1973 to 1977 at Winconsin Country). 7,642 girls and 751 boys were screened for spinal deformity. In initial screening , students were examined by Red Cross lay volunteers using forward-bending test. Any child with questionable abnormality was referred for further screening which was done by physical therapist or nurse. Children with abnormalities noted in the second screening were referred to orthopaedic surgeon for final screening. Prior to final screening standing roentgenograms of the entire thoracic and lumbar spine were obtained and read by the orthopaedist. Children who required immediate treatment or close observation were referred for private care while others requested to return for re-evaluation. In most cases at six months interval.
LE	II-3
Number of patients and patient characteristics	8,393 school children -7,642 girls and 751 boys. Grades fifth to tenth for girls and seventh and eighth for boys.
Intervention	Scoliosis screening using forward-bending test, radiography.
Comparison	
Length of follow up	Minimum 6 months to 5.3 years, an average of 1.5 years.
Outcome measures / Effect size	243 girls and 30 boys were found to have scoliosis. An overall incidence of scoliosis of 3.2% for girls and 4.0% for boys. 155 girls and 13 boys had curves ≥ 10° with an overall incidence of 2.0%. Incidence of 2.0% for girls and 1.7% for boys. 37 girls and 1 boy had curves ≥ 20° with an overall incidence of 0.4%. Incidence of 0.5% for girls and 0.1% for boys. 98% of those with scoliosis were classified as idiopathic. 18 girls required treatment when first seen, 10 with Milwaukee brace and 8 spinal fusion. Number needed to screen to identify one child with Cobb angle ≥ 10° was 50 (8,383/168), Cobb angle of: ≥ 20° was 221 (8,393/38). Number needed to screen to identify one child who subsequently receive treatment was 466 (8,393/18). Progression of curves 186 girls and 22 boys were followed up for 6 months or longer. During the follow-up period 141 (75.8%) girls and 20 (90.9%) boys had no change in the degree of curve. 24 (12.9%) girls and 1 (4.5%) boy had decrease in their curve of at least 5° and 21 (11.3%) girls and 1 (4.5%) boy had an increase in their curve of at least 5°. Determination of which curves would progress was unpredictable and identification of progression was possible only by repeated examinations.
General Comments	

Evidence Table : Effectiveness
Question : Is school scoliosis screening effective in detecting scoliosis ?
No. 6

Bibliographic Citation	Gurr JF. A school screening program that works. The Canadian Nurse. 1977; 73(12):24-29.
Study Type / Methodology	Retrospective cross-sectional study. Records of school screening in Montreal between 1974 and 1976. Screening was conducted by school nurses in the school using the forward-bending test. The subsequent phase of the program is carried out in medical centre and consists of three types of clinics: secondary screening clinic, regular follow-up clinic and brace clinic
LE	II-3
Number of patients and patient characteristics	26,947 school children in grades seven and eight.
Intervention	Scoliosis screening Adams forward-bending test, radiography.
Comparison	
Length of follow up	
Outcome measures / Effect size	4.6% had scoliosis based on Cobb angle ≥ 6°. 4.5% were idiopathic. There was 2% incidence of idiopathic scoliosis with curves greater than 10°. In curves that were ≥ 21°, girls predominate by 5.4 to 1. Over the 24 month period 2.75 students per 1000 screened were treated with braces.
General Comments	

Evidence Table : Effectiveness
Question : Is school scoliosis screening effective in detecting scoliosis ?
No. 7

Bibliographic Citation	Dickon RA, Stamper P, Sharp A *et al.* School screening for scoliosis: cohort study of clinical course. British Medical Journal. 1980; July: 265-267.
Study Type / Methodology	Cross sectional study. 1,764, 13 and 14 years old in five Oxford schools were screened for the presence of spinal deformity by visual inspection –forward-bending test. Those showing evidence of asymmetric body topography were examined with low dose spinal radiography in erect position. The radiographs measured by Cobb's method and those children with scoliosis of 10° or more were examined clinically. One year later the children were re-examined and radiographs taken using low dose technique to assess progression.
LE	II-3
Number of patients and patient characteristics	1,764 school children aged 13 and 14 years.
Intervention	Scoliosis screening using Adams forward-bending test and radiography.
Comparison	
Length of follow up	1 year
Outcome measures / Effect size	Of 1,764 school children screened, 147 (8.3%) showed asymmetry of body topography and 121 of these (6.9%) had radiographic evidence of scoliosis. 44 (2.5%) children had curves ≥ 10°. 2 had congenital abnormalities and 42 were classified according to the type of curve: sacral tilt (compensatory = 15), spinal (idiopathic = 18), or combined (sacral tilt and spinal = 9). Progression occurred in 6 (14%) of children with non congenital scoliosis. Progression did not occur in the sacral tilt group.
General Comments	

Evidence Table : **Effectiveness**
Question : **Is school scoliosis screening effective in detecting scoliosis ?**
No. 8

Bibliographic Citation	Velezis MJ, Sturm PF, Cobey J. Scoliosis screening revisited: Findings from the District of Columbia. Journal of Paediatric Orthopaedics. 2002; 22:788-791.
Study Type / Methodology	Retrospective cross sectional study. Review of scoliosis screening data collected by school health nurses annually from 1985 to 1996. The data collected included 20 variables for all in the sixth and eight grades follow-up data for a portion of the referred students in the District of Columbia's public schools. Screening conducted using forward bend test. Scoliosis screening was required for all in the sixth and eight grades. Nurses completed referral form for each student with a positive finding. Nurses were responsible for follow-up 1 year after the initial referral by direct contact with the parents or through forms sent back by a private physician.
LE	II-3
Number of patients and patient characteristics	52,300 students.
Intervention	Scoliosis screening using forward-bending test.
Comparison	
Length of follow up	1 year
Outcome measures / Effect size	During the school years 1989 to 1990 and 1995 to 1996, 52,300 students were screened to detect scoliosis. Of those screened only 1,218 (2%) were referred for further evaluation. Only 47% of these students reported for care. Only 223 students (18%) provided any definitive information on the type of care or degree of curve. Of the 223 students, 167 students (75%) received treatment (observation, brace or surgery). Findings indicate that many of the referred case were never followed up. Thus, it is difficult to know the true prevalence of scoliosis.
General Comments	

Evidence Table : **Effectiveness**
Question : **Is school scoliosis screening effective in detecting scoliosis ?**
No. 9

Bibliographic Citation	Smyrnis PN, Valavanis J, Alexopoulos A *et al.* School screening for scoliosis in Athens. The Journal of Bone and Joint Surgery. 1979; 61-B (2):215-217.
Study Type / Methodology	Cross sectional study. 3,494 children were randomly selected from 37,391 school children in the sixth grade in Athens in 1974. The bending test was used for clinical screening. Children with clinical evidence of rib humps or lumbar protrusion were then instructed to come to the hospital for evaluation where clinical findings and a standing anteroposterior radiograph of the thoracolumbar spine was taken. 112 with curves of 7° to 16° were followed-up for an average time of 19 months.
LE	II-3
Number of patients and patient characteristics	3,494 school children in the sixth grade. Of these children 79% were aged between eleven and twelve, 19% were over 12 and 2% under eleven.
Intervention	Scoliosis screening using forward-bending test and radiograpgh
Comparison	
Length of follow up	Average 19 months
Outcome measures / Effect size	362 (10%), showed abnormality on bending test and 222 (6.4%) showed radiographic evidence of abnormal curvature.(9.1% girls and 3.1% boys). For curves of ≥ 10°, the incidence was 4.6% for girls and 1.1% for boys. 112 with curves of 7° to 16° were followed-up for an average time of 19 months. The curves in girls showed greater tendency to progress as did larger curves in both sexes. 77.8% of the right thoracic curves showed deterioration.
General Comments	

Evidence Table : **Effectiveness**
Question : **Is school scoliosis screening effective in detecting scoliosis ?**

No. 10

Bibliographic Citation	Pin LH, Mo LY, Lin L *et al.* Early diagnosis of scoliosis based on school-screening. The Journal of Bone and Joint Surgery.1985;67-A(8):1202-1205
Study Type / Methodology	Cross sectional study. In 1983, a total of 8,165 children in primary school and in the first grade of the middle school in the northern district of Changsa and at the Lian Yuan Steel Plant were screened for scoliosis by two teams of orthopaedic surgeons. The first team working in Changsa examined 5,457 children, while the second team working in Lian Yuan examined 2,708 children. Screening include physical examination which include forward-bending test. Any child who had a positive bending test (the difference in the heights of the sides exceeding five mm), an anteroposterior roentgenogram was made while the child was standing. Follow up study consisted of repeat roentgenographic examination of 304 children who had curves that ranged from 1° to 19°.
LE	II-3
Number of patients and patient characteristics	8,165 school children aged 6 to 15 years. There were 4,202 (51.5%) boys and 3963 (48.5%) girls.
Intervention	Scholiosis screening using physical examination which include forward-bending test, anteroposterior roentgenogram while the child was standing.
Comparison	
Length of follow up	1 year for 304 children
Outcome measures / Effect size	790 children had positive physical findings and 689 (87%) of them had a roentgenographic examination. The prevalence of curves of ≥ 5° was 6.6%, of ≥ 10° was 2.4% and ≥ 20° was 0.14%. A follow up study after 1 year of children who had been reported to have scoliosis (304) showed that only 47.9% remained unchanged, while 20.7% regressed, 8.5% improved, 18.4% altered and 4.9% deteriorated. Number needed to screen to identify one child with a Cobb angle of ≥ 10° was 48 (8,165/171) and Cobb angle of ≥ 20° was 816 (8,165/10).
General Comments	

Evidence Table : **Effectiveness**
Question : **Is school scoliosis screening effective in detecting scoliosis ?**

No. 11

Bibliographic Citation	Ohtsuka Y, Yamagata M, Arai S *et al.* School Scoliosis screening for scoliosis by the Chiba University Medical School Screening Program. Results of 1.24 million students over an 8-year period. SPINE. 1988;13(11):1251-1257
Study Type / Methodology	Retrospective cross sectional study. The screening program for scoliosis started by Chiba University Japan in 1979 consists of using moiré topography, low dose roentgenography and a final ordinary x-ray examination. The result of 1.24 million students screened during the 8-year period from 1979 to 1986 was analyzed.
LE	II-3
Number of patients and patient characteristics	1,246,798 school children in the 5th and 6th grade primary schools and 1st and 2nd grade junior high school.
Intervention	School scoliosis screening using moiré topography, low dose roentgenography and a final ordinary x-ray examination.
Comparison	
Length of follow up	
Outcome measures / Effect size	The incidence of scoliosis of more than 15° increased linearly according to age from the fifth grade primary school children (0.07% in boys, 0.44% in girls) to the second grade junior high school students (0.25% in boys, 1.77% in girls). The female predominance of scoliosis cases with curvatures of more than 20° detected during the total period was 10:1 and was the same for primary school children and junior high school students.
General Comments	

Evidence Table : **Effectiveness**
Question : **Is school scoliosis screening effective in detecting scoliosis ?**
No. 12

Bibliographic Citation	Prujis JEH, van der Meer, Hageman MAPE *et al.* The benefits of school screening for scoliosis in the central part of the Netherlands. Eur Spine J. 1996; 5:374-379
Study Type / Methodology	Cross sectional study. In this study three cohorts of 10,000 children each, of initially 10, 12 and 14 years of age, respectively, attending schools in the central part of The Netherlands were chosen. The pupils were examined within the schedule of the periodic health checks (PHC, biennial) as well as in complimentary screening sessions (CSS, alternate year), and followed subsequently for 3 years during the period 1983-1987. All children from these cohorts who were found positive were classified into group 1 (new cases). Those who had previously been referred for scoliosis were registered and classified into group 2 (previously known cases). Screening for scoliosis was performed by 40 participating schools physicians. They conducted bending test during the normal periodic health check (PHC) of appropriate classes, and in an extra session (CSS) for classes not due for PHC until the following year, examining only for scoliosis. Each child with a positive bending sign had to be referred to moiré session. All children in whom one or more tests were positive (group 1) were advised to visit general practitioner which refer the child to orthopaedic surgeon if scoliosis is suspected.
LE	II-3
Number of patients and patient characteristics	30,611 school children aged 10 to 16 years old.
Intervention	School scoliosis screening during the normal periodic health check (PHC) and extra session (CSS)
Comparison	
Length of follow up	3 years
Outcome measures / Effect size	The annual screening programme identified 57 new cases of severe scoliosis (Cobb angle >19°). Together with the 34 cases already known, the prevalence amounted to 91 out of 30,000 (0.3%). Among the newly identified group, ten children (18%) were treated conservatively; the equivalent figure for the previous identified group was 17 children (50%). None of the newly identified group needed surgery, whereas two children from the previously identified group were operated. Continuation of regular periodic checks biennially including quantification of trunk asymmetry among these age groups would enable all scoliosis over 19° of Cobb angle to be detected.
General Comments	

Evidence Table : **Effectiveness**
Question : **Is school scoliosis screening effective in reducing the need for surgical treatment?**

No. 1

Bibliographic Citation	Bunge EM, Juttmann RE, van Biezen FC *et al.* Estimating the effectiveness of screening for scoliosis: A case- control study. PEDIATRICS. 2008;121(1):9-14
Study Type / Methodology	Case - control study. A total of 125 consecutive patients who were treated surgically for idiopathic scoliosis between January 2001 and October 2004 and who were born on or after January 1, 1984 were invited of which 108 (86%) agreed to participate. A total of 216 control subjects were selected randomly and anonymously, matched with respect to age and gender. For 279 adolescents exact screening exposure and outcomes could be analyzed. Case subjects were recruited from 4 university and 6 non university Dutch hospitals: control subjects were recruited from all 37 municipal health services in the Netherlands.
LE	II-2
Number of patients and patient characteristics	Case 108 patients with idiopathic scoliosis who were treated surgically (80% girls and 20% boys). Control group consisted of a random sample of Dutch Youths.
Intervention	Exposure to screening before idiopathic scoliosis was diagnosed. Being exposed to screening was defined as being examined for scoliosis during a periodic medical examination or a “single scoliosis screening” with at least Adam’s forward-bending test.
Comparison	Not exposed to screening
Length of follow up	
Outcome measures / Effect size	Screen detected patients had significantly smaller Cobb angles at diagnosis, compared to otherwise detected patients, mean 34º ± 16.1 (SD) versus mean, 46º ± 13.3 (SD), p<0.01. Screen detected patients were diagnosed at a significantly younger age than otherwise detected patients’ mean, 10.8± 2.6 (SD) versus mean, 13.4± 1.7 (SD) years. Screen detected patients had an almost threefold greater chance of being treated with brace before surgery (OR : 3.1; 95% CI=1.3 to 7.0) In total, 32.8% of surgically treated patients had been screened between 11 and 14 years of age, compared to 43.3% of control subjects. The odds ratio (OR) for being exposed to screening at the age of 11, 12, 13 or 14 years and getting surgery was 0.64 (95% CI=0.34 to 1.19, p = 0.16). Twenty eight percent of patients were diagnosed as having scoliosis before 11 years of age. Conclusion Our results showed no evidence that screening for scoliosis reduced the need for surgery by 50%.
General Comments	Quality assessment (CASP) 1. Yes 2. Yes 3. Yes 4. Yes 5. Yes 6. Yes 7.OR, CI not sig.

Evidence Table : Effectiveness
Question : Is school scoliosis screening effective in reducing the need for surgical treatment?

No. 2

Bibliographic Citation	Bunge EM, Juttmann RE, de Koning HJ *et al.* Screening for scoliosis: do we have indications for effectiveness?. Journal of Medical Screening. 2006;13(1):29-33
Study Type / Methodology	Retrospective cross sectional study. Retrospective follow-up study of patients with adolescent idiopathic scoliosis who had completed treatment with a brace, surgery or with a brace followed by surgery. Orthopaedic surgeons from 12 hospitals in the Netherlands where the patients with scoliosis were requested to report all consecutive patients who had completed treatment for idiopathic scoliosis between June 2002 and October 2004 and who were born on of after 1 January 1984. Of the 143 eligible patients who were invited to participate, 125 (87%) gave their informed consent. Of these 51 patients were treated with brace only and 74 patients were operated on. Screening for scoliosis is carried out in 80% of Dutch children. Data on being screen detected or otherwise detected and Cobb angle at diagnosis were collected using youth health-care files, medical files and interviews by telephone with the patients.
LE	II-3
Number of patients and patient characteristics	125 patients (82% girls and 18% boys)
Intervention	Exposure to screening
Comparison	Not exposed to screening
Length of follow up	
Outcome measures / Effect size	Of the 125 patients in the total study group, 66 (55%) were detected by screening and 53 were detected otherwise. Remaining two patients data on detection were missing,, and for four patients it was not possible to judge whether they were detected by school physician or otherwise. Screen detected patients had significantly smaller Cobb angles at diagnosis, compared to otherwise detected patients mean, 28°,(SD=12.6) versus mean, 40°, (SD=15.7), p<0.01. Patients detected by screening are significantly younger at detection and at diagnosis than otherwise–detected patients. (Detection: mean, 9.9 (SD=2.6) versus mean, 12.6 (SD=2.4) p<0.01). (Diagnosis: mean, 10.9 (SD=2.5) versus mean 13.1(SD=2.5), p<0.01. 45% of screen-detected patients needed surgery, compared to 75% of the otherwise-detected patients. The odds ratio (OR) for surgery for screen detected was 0.27 (95% CI=0.12 to 0.60). This means that patients who were detected by screening had a 73% lower chance of an adverse outcome (needing surgery). Conclusion. In the present study, two essential prerequisites necessary for a screening programme for scoliosis to be effective have been met. However, definite proof of the effectiveness of screening still needs to be established because length bias and over-treatment bias cannot be ruled out using this design.
General Comments	

Evidence Table : **Effectiveness**
Question : **Is school scoliosis screening effective in reducing the need for surgical treatment?**

No. 3

Bibliographic Citation	Montgomery F, Wilner S. Screening for idiopathic scoliosis. Comparison of 90 cases shows less surgery by early diagnosis. Acta Orthop Scand. 1993;64(4):456-458
Study Type / Methodology	Observational (Before and after study) Assessed the final outcome of curve progression in 90 consecutive school children with idiopathic scoliosis. Forty six children treated before screening (1971-1976) were compared with 44 children treated during screening (1978-1981), after introduction of school screening in 1977. Indication for surgery was defined as a curve that progresses to a Cobb's angle of 45° or more, whether surgery was subsequently performed or not.
LE	II-3
Number of patients and patient characteristics	90 consecutive schoolchildren
Intervention	Conventional screening program involving annual mandatory screening of all school children between the ages of 7 and 16
Comparison	No screening
Length of follow up	2 years after cessation of growth or until an operation has been performed
Outcome measures / Effect size	The risk of deterioration to 45° in children, diagnosed and qualified for treatment before screening period was 8 times greater than after screening (OR = 7.9, 99% CI =1.6 to 36).
General Comments	

Evidence Table : **Effectiveness**
Question : **Is school scoliosis screening effective in reducing the need for surgical treatment?**

No. 4

Bibliographic Citation	Lonstein JE, Bjorklund S, Wanninger MH. Voluntary school screening for scoliosis in Minnesota. The Journal of Bone and Joint Surgery.1982; 64-A(4):481-488
Study Type / Methodology	Cross sectional study Reviewed the experience in Minnesota over the past eight years (1973-1980), with an average of one quarter of a million children being screened yearly. Screenings were performed in schools usually during a physical education class. Two screeners usually work together. One observing the result of Adams test and the other acting as a recorder. A difference in the levels of the two sides of the back in the thoracic or lumbar area is recorded as a positive screening.
LE	II-3
Number of patients and patient characteristics	Students in grades five through nine (ages ten to fourteen years). Approximately quarter of a million yearly.
Intervention	School scoliosis screening
Comparison	
Length of follow up (if applicable)	
Outcome measures / Effect size	Of the children screened 3.4 % were referred for evaluation and scoliosis was found in 1.2%. The percentage of children requiring surgery has declined from 30, (0.017%) in the 1974 to 1975 school year to 11, (0.004%) in the 1979 to 1980 school year. The percentage of children requiring brace has declined from 224, (0.0125%) in the 1974 to 1975 school year to 95,(0.037%) in the 1979 to 1980 school year The mean size of the major curve at the time of operation decreased from 60° in 1971 to 42° in 1979.
General Comments	

Evidence Table : Economic evaluation
Question : What is the cost / cost-effectiveness of school scoliosis screening ?
No. 1

Bibliographic Citation	Yawn BP, Yawn RA. The estimated cost of school scoliosis screening. SPINE. 2000;25(18):2387-2391
Study Type / Methodology	Retrospective cross sectional study of one community's school–based scoliosis screening program in Rochester. School scoliosis screening results were linked with the medical and chiropractic care records of all referred children to identify outcomes and scoliosis –related health utilization from Grade 5 through graduation or age 19 years. Costs were presented per child screened, per child with a spinal curve of 20° or more, and per child treated for scoliosis and are based on scoliosis–related health care utilization and school costs.
LE	
Number of patients and patient characteristics	2,242 school children.
Intervention	Scoliosis screening in the schools using Adams forward- bending test, and scoliometer. and spine x-rays
Comparison	
Length of follow up	Follow-up to age 19 years or until they left the school district.
Outcome measures / Effect size	Ninety-two (4.1%) of 1,297 children screened were referred for further evaluation of possible scoliosis and 68 (74%) of those had documented evaluation for possible scoliosis. Five of the 92 children referred were treated for scoliosis by age 19. Sixty-six scoliosis-related primary care visits, 79 scoliosis –related orthopaedist visits, and 79 full spine radiographs. Case finding costs for screening were $24.66 per child screened (n=2,179), $3,386.25 per child with a curve of 20° or more (n=16) and $10,836.00 per child treated for scoliosis (n=5). Note* = cost analysis based on service charge and school costs. Does not include indirect cost. Based on primary care visits, specialty visits, radiographic films and school costs.
General Comments	

Evidence Table : Economic evaluation
Question : What is the cost / cost- effectiveness of school scoliosis screening ?
No. 2

Bibliographic Citation	Montgomery F, Persson U, Benoni G *et al.* Screening for scoliosis. A cost-effectiveness analysis. SPINE. 1990;15(2)67-70
Study Type / Methodology	Cost-effectiveness using data from retrospective studies in Malmo, Sweden. Cost- effectiveness of three different screening methods was studied: i) no specific screening ii) conventional clinical screening (Adam bend test) iii) combined conventional clinical screening and Moire screening. A multistage model of the treatment process was developed.The costs for health care and production lost were calculated and applied to the time profiles of the three screening alternatives. Health care costs – costs of screening, costs of false positive, costs for brace treatment, cost for surgery. Production loss – loss for parents accompanying the child for an outpatient visit, production loss for parents taking care of the child postoperatively for 6 weeks.
LE	
Number of patients and patient characteristics	Three cohorts of school children in Malmo, each cohort involving three age groups. No specific screening was used for children born between 1959 and 1961 (9,212) and the conventional clinical screening for children born between 1965 and 1967 (9,136).
Intervention	i) no specific screening ii) conventional clinical screening (Adam bend test) iii) combined conventional clinical screening and Moire screening.
Comparison	
Length of follow up	
Outcome measures / Effect size	Total costs per screen (health care and production Loss):- No specific screening = $ 33.90 Conventional clinical screening = $ 43.70 Combined clinical Moire Screening = $ 27.70 The combined clinical moiré screening would be the cost effective way of using resources to prevent scoliosis from developing into a more severe deformity.
General Comments	

Evidence Table : **Economic evaluation**
Question : **What is the cost / cost- effectiveness of school scoliosis screening ?**
No. 3

Bibliographic Citation	Thilagaratnam S. School-based screening for scoliosis: is it cost-effective?. Singapore Med J. 2007; 48(11):1012
Study Type / Methodology	Cost-effectiveness analysis. This cost-effectiveness analysis was done by comparing Singapore's existing school-based scoliosis screening and follow-up programme with the alternative of not having the programme. As the aim of the existing programme was to detect curves early, allowing bracing to be initiated and reducing the need for surgery, this analysis assumed that without the programme, students who otherwise would have received bracing and not needed surgery, would have required surgery instead. This retrospective analysis was based on school health service data obtained from screening 45,485 students in 1999 and 44,051 of this same cohort in 2001. Nett programme costs and health effects were computed, and a decision rule applied. Cost include direct and indirect cost.
LE	
Number of patients and patient characteristics	45,485 students (11-12 year olds) in 1999 and 44,051 of this same cohort in 2001
Intervention	School scoliosis screening
Comparison	No screening
Length of follow up	
Outcome measures / Effect size	The total cost to screen, follow-up and treat (bracing 36 students and surgery 21 students) the 1999 cohort of primary six students over the three year period from 1999 to 2001 was SGD 1,063,010.82. It was assumed that without screening programme, all students who had their curves braced (36 in total) would have had surgery in addition to the 21 students who had surgery even with screening programme. The total of SGD 1,358,104.80 was the sum of the direct costs of surgery and follow-up, and the indirect costs, comprising time costs for the parents accompanying the child for surgical admission and follow-up visits. Nett cost, which is the difference between the cost of the programme and the 'saving' in the absence of the programme, was minus SGD 295,093.98. A sensitivity analysis was performed by varying the numbers who would need surgery. Even if only about 65% of the 36 patients required surgery, the nett cost remains negative. Conclusion : Singapore's school-based scoliosis screening programme which is implemented as part of a larger school screening and immunisation programme is cost-effective. Cost-effectiveness may be further improved by targeting screening at high risk groups, such as prepubertal females. More research is needed to quantify the positive health effects of scoliosis screening.
General Comments	

Evidence Table : **Economic evaluation**
Question : **What is the cost / cost- effectiveness of school scoliosis screening?**
No. 4

Bibliographic Citation	Morais T, Bernier M, Turcotte F. Age-and sex-specific prevalence of scoliosis and the value of school screening programs. AJPH. 1985; 75(12):1377-1280
Study Type / Methodology	Cross sectional study. In 1977 to 1978, a total of 29,195 children aged 8 to 15 years were screened for idiopathic scoliosis in Quebec. Screening was performed in the schools, each child being examined by two specially trained nurses. Clinical inspection of the symmetry of the back using the forward-bending test performed. Unequal rib prominence or unilateral lumbar protrusion on bending forward was defined as positive sign for scoliosis. A screening record was completed for each child with a positive test. Each referred child was first to undergo clinical examination by an orthopaedic surgeon, followed by an x-ray of the spine when deemed necessary. Any curve of 5° or more, as measured by the Cobb method was reported as a case of scoliosis.
LE	
Number of patients and patient characteristics	29,195 children aged 8 to 15 years 14,689 girls and 14,506 boys
Intervention	Scoliosis screening in schools using forward-bending test and x-ray of the spine
Comparison	
Length of follow up	
Outcome measures / Effect size	Direct cost of screening test. Screening costs include diagnostic costs and cover salaries, transportation, communications, and filing costs but exclude research costs. Professional fees and radiological services make up clinical confirmation costs. Costs were expressed in 1979 Canadian dollars. Screening of 29,195 children cost $ 67,440 with an average $2.31 per child. Clinical evaluation of 2,868 positive screeners cost $170,933 or $59.60 per child referred including the cost of x-rays. From the total costs of $238,373, the cost per case of confirmed scoliosis is estimated at $194.27 and the cost per case of scoliosis brought to immediate treatment is $3,505.49.
General Comments	

Evidence Table : Economic evaluation
Question : What is the cost / cost- effectiveness of school scoliosis screening?
No. 5

Bibliographic Citation	Lonstein JE, Bjorklund S, Wanninger MH. Voluntary school screening for scoliosis in Minneota. The Journal of Bone and Joint Surgery.1982; 64-A(4):481-488
Study Type / Methodology	Cross sectional study Reviewed the experience in Minnesota over the past eight years (1973-1980), with an average of one quarter of a million children being screened yearly. Screenings were performed in schools usually during a physical education class. Two screeners usually work together. One observing the result of Adams test and the other acting as a recorder. A difference in the levels of the two sides of the back in the thoracic or lumbar area is recorded as a positive screening.
LE	
Number of patients and patient characteristics	Students in grades five through nine (ages ten to fourteen years). Approximately quarter of a million yearly.
Intervention	School scoliosis screening
Comparison	
Length of follow up	
Outcome measures / Effect size	The salary of sate nurse coordinator, as well as the costs of workshop manuals, brochures, and mailing totalled $ 16,560 in 1980. Cost per student screened amount to 6.6 cents per student. The cost if the time of the school staff had to be funded. Average cost per screening $190, with an average of eighteen hours per year required for planning, set-up, students education, screening and follow-up. This would amount to 35 cents per student screened and could range from twenty four cents to $1.75 per student screened. This is so called time cost is what the program would cost if the salary of the screeners had to be funded and if the country and state nurses salaries were included.
General Comments	

Evidence Table : Economic evaluation
Question : What is the cost / cost- effectiveness of school scoliosis screening?
No. 6

Bibliographic Citation	Soucacos PN, Soucacos PK, Zacharis KC *et al.* School-screening for scoliosis. A prospective epidemiological study in Northwestern and Central Greece. The Journal of Bone and Joint Surgery. 1997; 79-A(10):1498- 1503
Study Type / Methodology	Prospective cross sectional study. (Period of 2 year between January 1993 and December 1994). A total of 82,901 children who were nine to fourteen years old were screened for scoliosis. Scoliosis screening teams consisting of a senior orthopaedic surgeon and staff member, an orthopaedic resident. Screening took place during Physical Education class. Physical examination and forward-bending test performed. If have at least one positive finding for scoliosis, which include asymmetrical shoulder levels, scapular prominence, unequal distance from the upper extremities to the flanks or inequality of the lengths of the lower limbs while child was standing, and a lateral deviation of the spine during the forward-bending test the child is re-examined to confirm criteria for referral. Rescreening A second forward-bending test performed and considered positive (a difference of more than five mm between the two sides of the torso as measured by in the thoracic or thoracolumbar region with use of a ruler and a level plane). The child was referred for radiographic evaluation.A curve with a Cobb angle of 10° or more was defined as having structural scoliosis.
LE	
Number of patients and patient characteristics	A total of 82,901 children, (41,939 boys and 40,962 girls) who were nine to fourteen years old.
Intervention	Scoliosis screening in the schools using forward-bending test, level plane and ruler and radiographic evaluation
Comparison	
Length of follow up	
Outcome measures / Effect size	Cost of screening program based only on transportation. Cost of the entire screening program approximately $25,000 or about thirty cents per child.
General Comments	

Evidence Table : Diagnostic accuracy of screening methods.
Question : What is the diagnostic accuracy of forward-bending test (FBT), Moire, Humpograms and scoliometer in detecting scoliosis ?

No. 1

Bibliographic Citation	Karachalios T, Sofianos J, Roidis N *et al.* Ten-year follow-up evaluation of a scoliosis screening program for scoliosis. Is forward-bending test an accurate diagnostic criterion for the screening of scoliosis?. SPINE.1999; 24(22):2318-2314
Study Type / Methodology	Cross sectional study. : In 1987, 2700 pupils aged 8 to 16 years from the island of Samos, Greece were screened for scoliosis. All pupils were clinically examined both by inspection (trunk asymmetry) and by the Adams forward-bending test (FBT). Each pupil found positive on clinical examination was isolated and clinical examination of the level and the side of curvature was recorded. Humpograms of the back of all pupils were taken using the humpometer. The parameter for back deformity (H+D) was recorded and considered positive when its value exceeded 5 mm. All pupils were examined using scoliometer. All recorded angle values greater than 0° were considered to show a positive result. All pupils were also examined using Moire topography. Pupils were classified as positive or negative in all the methods used for the detection of scoliosis by two independent evaluations and the consequent recordings of the two orthopaedic examiners of each examining group. Finally all found positive on either clinical examination and FBT or in any of the back-shape analysis methods were subjected to conventional anteroposterior standing radiological examination. Because this scoliosis screening test was followed by a screening test for lung diseases, low dose long chest radiographs were also obtained and were available for the remainder of the pupil. All pupils in whom spinal deformity was diagnosed, were observed and follow up regularly at yearly intervals. A 10 year clinical and radiologic follow-up evaluation of these was done in 1997. The remaining subjects were re-evaluated by a postal questionnaire and were clinically examined if necessary.
LE	2
Number of patients and patient characteristics	2,700 pupils aged 8 to 16 years
Intervention	Scoliosis screening using Adams forward-bending test (FBT), humpograms, scoliometer, Moire topography and conventional anteroposterior standing radiological examination and low dose long chest radiographs
Comparison	
Length of follow up	10 years

Outcome measures / Effect size	Diagnostic accuracy. Spinal deformity was found in 153 (5.66%) of the pupils. Scoliosis defined as a spinal curvature of ≥ 10° was found in 32 pupils, prevalence of 1.18%. **Diagnostic accuracy for screening methods in detecting scoliotic curvatures (Cobb angle ≥ 10°:-** **FBT** Sensitivity = 0.84 Specificity = 0.93 PPV = 0.13 NPV = 0.99 (5 cases of false negative results) **Moire** Sensitivity = 1.00 Specificity = 0.85 PPV = 0.07 NPV = 1.00 **HUMP A ≥ 5 mm** Sensitivity = 0.93 Specificity = 0.78 PPV = 0.04 NPV = 0.99 **HUMP B ≤ 5 mm** Sensitivity = 0.87 Specificity = 0.78 PPV = 0.02 NPV = 0.99 **Scoliometer (ATR > 0°)** Sensitivity = 0.96 Specificity = 0.79 PPV = 0.05 NPV = 0.99 Significant correlation between Cobb angle and fringe asymmetry in all spinal curvatures. Humpogram showed significant correlation with Cobb angle in thoracic spinal curvatures. No correlation between angle of scoliometer and the Cobb angle. In Moire topography, when the asymmetry was two fringes or more, all the underlying scoliotic curvatures had a Cobb angle of 10° or more. For the humpograms when the parameter H+D was 10mm or more, the the underlying scoliotic curvatures had a Cobb angle of 10° or more. Similarly a scoliometer angle of 8° or more reflected a curvature of 10° or more. Interrater agreement in the assessment of Moire asymmetry was 85%, for humpogram deformities 88%, for scoliometer angles 80%, and for FBT 88%. Time spent for Moire topography was 40 seconds per person, scoliometer 20 seconds, humpogram 1 minute 10 seconds and FBT 30 seconds. During this scoliosis screening program, if cut off limits for referral had been used such as asymmetry of two Moire fringes, a humpogram deformity = 10mm, and 8°of scoliometer angle, it would have been possible to reduce radiologic examination by 89.4%. Conclusison The Adam forward-bending test cannot be considered a safe diagnostic criterion for the early detection of scoliosis (especially when it is used as the only screening tool) because it results in unacceptable number of false negative findings. For early detection of scoliosis a combination of back-shape analysis methods can be safely used with the introduction of cut off limits for referral.
General Comments	Quality assessment (CASP) 1. Yes 2. Yes 3.Yes (CR/LD) 4. No (no blinding) 5. Yes 6. Yes 7. Sen, spec, PPV, NPV. 8. CI not mentioned

Evidence Table : **Diagnostic accuracy of screening methods.**
Question : **What is the diagnostic accuracy of forward-bending test in detecting scoliosis ?**

No. 2

Bibliographic Citation	Goldberg CJ, Dowling FE, Fogarty EE *et al.* School scoliosis screening and the United States Preventive Services Task Force. An examination of long term results.SPINE.1995; 20(12):1368-1374
Study Type / Methodology	Cross sectional study. New entrants (1986-1987) to the screening program were used to test the validity of the screening methods. The screening test used was the Adams forward bend. A three-tier screening system was evolved in which first examination was done by a doctor from the School Medical Services in national primary schools and by physical education teacher or school nurse in post-primary schools. Referrals from school doctors were reviewed in the screening clinic at Our Lady Hospital of Sick Children, Dublin. Radiography was recommended on the basis of scoliometer reading and maturity. For validity estimate scoliosis was defined as a child whose scoliosis passed 40° at diagnosis or subsequently. After 1-4 years 5179 were re-examined and used in validity calculation.
LE	3
Number of patients and patient characteristics	8,686 girls who entered the screening program for the first time. Mean age was 12.9 years, standard deviation =1.4
Intervention	Scoliosis screening using Adams forward bend test and Radiography
Comparison	
Length of follow up	
Outcome measures / Effect size	Diagnostic accuracy. In the year 1986-1987 there were 8,686 girls who entered the screening program. After primary and secondary screening 8,608 were considered normal with 17 non attenders. After the interval of 1-4 years, 5,179 were re-examined and used in the validity calculation. After the final assessment in the screening clinic in 1986 to 1987, 61 girls were deemed test positive and sent for radiographic investigation. A total of five girls were scoliosis positive (Cobb angle ≥ 40°). Diagnostic accuracy for Cobb angle ≥ 40° , Sensitivity = 0.83 Specificity = 0.98 PPV = 0.08
General Comments	Quality assessment (CASP) 1. Yes 2. Yes 3. No (verification bias) 4.No (no blinding) 5. Yes 6. Can't tell 7. Sen, spec, PPV 8. CI not mentioned

Evidence Table : **Diagnostic accuracy of screening methods.**
Question : **What is the diagnostic accuracy of RHH, ATR and Moire topography in detecting scoliosis ?**

No. 3

Bibliographic Citation	Prujis JEH, Keesen W, van der Meer R *et al.* School screening for scoliosis: the value of quantitative measurement.Eur Spine J. 1995; 4:226-230
Study Type / Methodology	Cross sectional study. Within a regional school screening project, in Netherland all children with a positive bending sign that is all children with apparent asymmetries were invited for a second inspection a so called moiré session. Three parameters of the back were quantified: rib hump height (RHH), angle of trunk rotation (ATR) and Moire topography (MT). In the case of RHH of 8mm or more in the thoracic or thoracolumbar region or a difference of 5 mm in the lumbar region is classified as positive. In the case of ATR measurement of 5° or more in all regions of the back is classified as positive. In the case of topography a difference of two lines or more in all regions of the back is classified as positive. Cobb angle served as gold standard
LE	3
Number of patients and patient characteristics	School doctors examined over 3 years, three cohorts of children of 10, 12 and 14 years of age. Each cohort consisted of 10,000 children. Out of these cohorts, 3,530 children were invited for the second examination of whom 3,069 were actually seen.
Intervention	Measurement of rib hump height (RHH), measurement of ATR and Moire topography and radiographic examination of the spine.
Comparison	
Length of follow up	
Outcome measures / Effect size	Out of 3,069 children, one or more of the three tests was found positive in 1931 (63%) of the children. In only one-third (671/1931) were able to evaluate the screening outcome by an orthopaedic examination and radiograph of the spine. No significant difference in the ability to detect scoliosis was found between the three techniques. Area under receiver operating curve (ROC curve) for RHH = 0.58 Area under receiver operating curve (ROC curve)for ATR = 0.56 Area under receiver operating curve (ROC curve) for MT = 0.59 Significant correlation of Cobb angle with RHH (coefficient correlation = 0.18, $p < 0.001$) and MT (coefficient correlation = 0.14, $p < 0.01$). No significant correlation with ATR. Concluded that measurement techniques are valuable in school screening programmes.
General Comments	Quality assessment (CASP) 1. Yes 2. Yes 3. No (verification bias) 4.No (no blinding) 5. Yes 6. Yes 7. Sen, spec, ROC 8. CI not mentioned

Evidence Table : **Diagnostic accuracy of screening methods.**
Question : **What is the diagnostic accuracy of scoliometer in detecting scoliosis ?**

No. 4

Bibliographic Citation	Huang SC. Cut- off point of the scoliometer in school scoliosis screening. SPINE. 1997;22(17): 1985-1989
Study Type / Methodology	Cross sectional study. In 1994, school screening for scoliosis was conducted in 202 schools throughout Changhua Taiwan to determine the ideal angle of trunk rotation cut-off point to be used for referral in school screening for scoliosis. Only female students in the fifth and sixth grades in elementary school and in the first grade in junior high school were included. Nurses were responsible for the primary screening using Adam forward bend test and scoliometer measurement of all student under the supervision of orthopedists. Students with angle of trunk rotation (ATR) of 5° or more in any of the thoracic, thoracolumbar, or lumbar areas were referred for secondary screening by radiographic examination. Individual with a Cobb angle of 10° or more were considered as having scoliosis.
LE	3
Number of patients and patient characteristics	34,234 female students in the fifth and sixth grades in elementary school and in the first grade in junior high school.
Intervention	Scoliosis screening using Adam forward bend test and scoliometer and radiographic examination of the spine.
Comparison	
Length of follow up	
Outcome measures / Effect size	Of 34,234 eligible students, 33,596 (98.1%) attended primary screening. The referral rate was 5.2% for students with ATR of 5° or more and would have been 2.4% for ATR of 6 ° or more, 1.4% for those with ATR of 7° or more, 0.7% for those with ATR of 8° or more, 0.5% for those with ATR of 9° or more, and 0.3% for those with ATR of 10° or more. The referral rate decreased as higher degrees of ATR were selected. The prevalence rate for scoliosis ≥ 10°, 20°, 30° or 40° of the Cobb angle was 1.47%, 0.21%, 0.04% and 0.02% respectively by using a 5° angle of trunk rotation as the criterion for radiography. Positive predictive value (PPV) was 28.3% or 0.28 for scoliosis of ≥10°, 4% or 0.04 for scoliosis of ≥ 20°, 0.8% or 0.008 for scoliosis of ≥ 30°and 0.4% or 0.004 for scoliosis of ≥ 40° with a 5° angle of trunk rotation as the criterion for referral. By selecting angles of trunk rotation larger than 5° as criteria for referral for radiography, the PPV increased, but positive cases with larger Cobb angles also decreased markedly. Conclusion The optimal cut-off point for referral when using the scoliometer in school screening of scoliosis is still difficult to determine.
General Comments	Quality assessment (CASP) 1. Yes 2. Yes 3. No (verification bias) 4.No (no blinding) 5. Yes 6. No 7. PPV 8. No CI, likelihood ratio

Evidence Table : **Diagnostic accuracy of screening methods.**
Question : **What is the diagnostic accuracy of Moire topography compared to forward-bending test in detecting scoliosis ?**

No. 5

Bibliographic Citation	Laulund T, Sojbjerg JO, Horlyck. Moire topography in school screening for structural scoliosis. Acta orthop scand. 1982;53:765-768
Study Type / Methodology	Cross sectional study. The study was carried out in the district of Herning, Denmark. School children, aged 10-17 years were screened for structural scoliosis at school. Clinical examination including forward bend test was carried out by school doctors and moiré topography carried out by one of the authors. An asymmetry of more than one contour line is designated a moiré positive. Girls suspected of having structural sc oliosis by the school doctor and girls with moiré positive picture had a clinical follow-up by an orthopaedic surgeon who had no knowledge of the inclusion criteria of each individual girl. Not all girls from the screening with suspected structural scoliosis were x-rayed. An x-ray examination was only carried out where the clinical follow-up examination suggested a scoliosis of 10° or more, or where there is disparity between the results of the different examinations was found.
LE	2
Number of patients and patient characteristics	1,034 girls 10 to 17 years of age in the fifth to ninth forms.
Intervention	Scoliosis screening comprising of clinical examination including forward-bending test and Moire topography and radiographic examination of the spine.
Comparison	
Length of follow up	
Outcome measures / Effect size	Diagnostic accuracy. A total of 989 of 1034 (95.6%) participated in the screening. The follow-up examination comprised of 195 girls of whom 135 had a moiré positive picture and 108 a positive clinical screening. Both parameters were found to be positive in 48 girls. Follow–up examination carried out by an orthopaedic surgeon resulted in x-ray examination in 83 girls. Of these, 41 suffered from a scoliosis of 10° or more, equivalent to a prevalence of 4.1% (CI=2.7to 5.5). In 39 girls the scoliosis had not been recognized previously. Moire topography detected 39 out of 41 confirmed scoliosis while clinical screening including forward-bending test revealed only 19 out of 41 scoliosis. The weakness of moiré topography is the large number of false positive results. **Moire topography:-** PPV = 0.29 NPP = 0.997 **Bending test** PPV = 0.18 NPV = 0.97 No linear correlation between the degree of lateral deviation, judged by x-ray examination and the difference in contour lines, judged b moiré topography.
General Comments	Quality assessment (CASP) 1. Yes 2. Yes 3. No (verification bias) 4.No 5. Yes 6. Yes 7. PPV, NPV 8. No CI

Evidence Table : **Diagnostic accuracy of screening methods.**
Question : **What is the diagnostic accuracy of Moire topograpgy in detecting scoliosis ?**

No. 6

Bibliographic Citation	Daruwalla JS, Balasubramaniam P. Moire topography in scoliosis. The Journal of Bone and Joint Surgery. 1985; 67-B (2):211-213
Study Type / Methodology	Cross sectional study. Moire topography was added to school scoliosis screening in Singapore in 1982 at the second their school screening programme. The results of 1342 contourgraphs were assessed in isolation, were used to study the accuracy of the method in predicting the radiographic location and magnitude of scoliotic curves. All were measured by both authors together without prior knowledge of clinical and radiological findings.
LE	2
Number of patients and patient characteristics	1,093 school children
Intervention	Scoliosis screening comprising Moire topography and radiographic examination of the spine.
Comparison	
Length of follow up	
Outcome measures / Effect size	In 1,093 children, 1,464 curves were confirmed radiologically, with a double curve in 355 children and triple curve in eight. Of these curves 696 were thoracic, 518 thoracolumbar and 250 lumbar. The location could be diagnosed accurately on Moire topography in only 790 (54%). Accuracy of identifying the site of the curve was 68% in the thoracic spine, 54% in the thoracolumbar spine, and 15% in the lumbar region. There were 12.7% false-positive results, and 4.3% false negatives. Of patients with a deviation of one moiré fringe, 76.5% had a curve of 15° or less; of those with a deviation of four fringes, 69% had a curve greater than 26°. The prediction of the Cobb angle was less accurate when there was a deviation of two or three fringes. It is suggested that moiré topography as screening device should be reserved for use in the second tier of screening, since the forward-bending test is an effective and cheap method for the first tier of a mass school-screening programme.
General Comments	Quality assessment (CASP) 1. Yes 2. Yes 3. Yes 4. No 5. Can't tell 6. No 7. Site of curve, prediction of Cobb angle 8. No CI

Evidence Table : **Diagnostic accuracy of screening methods.**
Question : **What is the diagnostic accuracy of forward-bending test and scoliometer in detecting scoliosis ?**

No. 7

Bibliographic Citation	Grossman TW, Mazur JM, Cummings RJ. An evaluation of the Adams forward bend test and the scoliometer in a scoliosis school screening setting. Journal of Pediatric Orthopaedics.1995; 15(4):535-538.
Study Type / Methodology	Cross sectional study. In 1990 to 1991, 954 sixth graders screened using Adams forward bend test and the scoliometer to detect truncal rotation or asymmetry in a school screening setting. Each child was screened indepently by two orthopaedic medical assistants. Medical assistants alternated the screening methods in a random fashion. Any evidence of rotational abnormality (hump) was considered a positive examination on Adams forward bend test. All scoliometer readings were recorded in degrees of angle of trunk rotation (ATR). A reading of ≥ 5° was considered to be abnormal.
LE	3
Number of patients and patient characteristics	954 sixth graders.
Intervention	Scoliosis screening using Adams forward bend test and scoliometer.
Comparison	
Length of follow up	
Outcome measures / Effect size	**ATR** (≥ 5°) 678 (71%) screened normal on both Adams bend test and scoliometer. 48 (5%) screened abnormal on both visual and scoliometer examinations. 105 (11%) with abnormal visual examinations who were normal with scoliometer. 123 (13%) with normal visual examinations who were abnormal by scoliometer. **ATR** ((≥7°) 13 (1.4%) with normal visual examination who were abnormal by scoliometer.
General Comments	Quality assessment (CASP) 1. Yes 2. No 3. No (verification bias) 4.No 5.No 6. No 7. Comparison bet. the two test 8. No CI

Evidence Table : **Safety**
Question : **Is exposure to radiation to patients undergoing scoliosis radiography safe?**

No. 1

Bibliographic Citation	Chamberlain CC, Hojnowski LS, Perkins A *et al.* Radiation doses to patients undergoing scoliosis radiography. The British Journal of Radiology. 2000; 73: 847-853
Study Type / Methodology	Cross sectional study. Computed the radiation doses associated with scoliosis radiography and investigated how these radiation doses are influenced by the weight of the patient. Recorded the radiographic technique factors of 61 consecutive patients undergoing scoliosis radiography. Values of patient effective dose were obtained using effective dose to energy factors for specific radiologic projections taking into account each patient's weight.
LE	
Number of patients and patient characteristics	61 consecutive patients (46 females and 15 males) undergoing scoliosis radiography.
Intervention	Radiography
Comparison	
Length of follow up	
Outcome measures / Effect size	The median patient age was17 years, and the median patient weight was 53 kg. Entrance skin air kerma values in the "chest region" were approximately a factor of four lower than those in the "abdomen region". The air kerma values increased by a factor of two when the patient weight increased from 30 kg to 70 kg. Approximately 80% of the total energy imparted to a patient undergoing a scoliosis examination was in the "abdomen region", with the remaining 20% imparted to the "chest region". Energy imparted increased with patient weight, and was approximately 3 mJ for a 30 kg patient and approximately 8 mJ for a 70 kg adult patient. Effective doses showed little correlation with patient weight, with an average-sized patient (50 kg) receiving an effective dose of approximately 140µSv. Patients undergoing scoliosis radiography receive effective doses that are low in comparison with other types of radiographic examination.
General Comments	

Evidence Table : **Safety**
Question : **Is exposure to radiation to patients undergoing scoliosis radiography safe?**

No. 2

Bibliographic Citation	Manninen H, Kiekara O, Soimakallio S *et al.* Reduction of radiation dose and imaging costs in scoliosis radiography. Application of large-screen image intensifier photofluorography. SPINE. 1988;13(4): 409-412
Study Type / Methodology	Cross sectional study (case series). Photoflurography using a large image intensifier (Siemens Optilux 57) was applied to scoliosis radiography and compared with a full-size rare-earth screen/film technique.
LE	25 adolescent patients
Number of patients and patient characteristics	Photoflurography
Intervention	
Comparison	
Length of follow up	
Outcome measures / Effect size	When scoliosis radiography (PA-projection) was performed on 25 adolescent patients, the photofluorographs were found to be of comparable diagnostic quality with full-size films. A close correspondence between the imaging techniques was found in the Cobb angle measurements as well as in the grading of the rotation with the pedicle method. The use of photofluorographs results in a radiation dose reduction of about one-half and considerable savings in direct imaging costs and achive space. Particularly suited for for follow-up and screening evaluation of scoliosis, but in tall patients the image field size 40 x 40 cm restricts its usefulness as initial examination.
General Comments	

APPENDIX 5

LIST OF EXCLUDED STUDIES

1. Mittal RL, Aggerwal R, Sarwal AK. School screening for scoliosis in India. The evaluation of a scoliometer. International Orthopaedics (SICOT).1987; 11:335-338

2. Viviani GR, Budgell L, Dok C *et al.* Assessment of Accuracy of the scoliosis school screening examination. AJPH.1984; 74 (5):497-498

3. Nissinen M, Heliovaara M, Ylikoski M *et al.* Trunk asymmetry and screening for scoliosis: a longitudinal cohort study of pubertal school children. Acta Paediatr. 1993; 82: 77-82

4. Ferris B, Edgar M, Leyshon A. Screening for scoliosis. Acta Orthop Scand.1988; 59(4): 417-418

5. Drennan JC, Campbell JB, Ridge H. Denver: A metropolitan public school scoliosis survey. Paediatrics. 1977; 60(2): 193-196

6. Adler NS, Csongradi J, Bleck EE. School screening for scoliosis. One experience in California using clinical examination and moiré topography. The Western Journal of Medicine. 1984; 141(5): 631-633

7. Stig Willner. Development of trunk asymmetries and structural scoliosis in prepuberal school children in Malmo: A follow-up study of children 10-14 years of age. Journal of Pediatric Orthopedics. 1984; 4: 252-455

8. Kapoor M, Laham SG, Sawyer JR. Children at risk identified in an urban scoliosis school screening program: a new model. Journal of Paediatric Orthopaedics B. 2008; 17: 281-287