Journal of Research and Practice on the Musculoskeletal System
JRPMS

Review Article

School Screening for Idiopathic Scoliosis

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Abstract

The purpose of this paper is to examine the effectiveness and cost-effectiveness of school screening for idiopathic scoliosis. To achieve this goal, a review of the international literature was conducted. Through the analysis of the findings, it can be concluded that school screening is an effective and cost-effective process, especially if some modifications with more specific targeting are incorporated, which can enhance the cost effectiveness even further.

Keywords: Cost-effectiveness, Effectiveness, Idiopathic scoliosis, School screening

Introduction

Scoliosis is a complex 3D deformity of the spine, which is characterized by a lateral inclination in the frontal plane, by thoracic lordosis and by rotation of the vertebrae. Scoliosis is the most common deformity of the spine in children and adolescents and a scoliosis curve is now considered pathological when it exceeds 10° (Cobb angle) on the anteroposterior X-ray[1].

Different types of scoliosis are classified according to the age of onset, type, severity or etiology. Each subtype exhibits different characteristics in terms of epidemiology, likelihood of worsening, kyphosis level, and three-dimensional spinal deformity. In all subtypes, however, a prognostic indicator for the condition is the early onset and the large size of the scoliotic curve[2].

According to the International Scoliosis Research Society, scoliosis is generally divided into two large groups, structural and nonstructural. A characteristic of nonstructural (or functional) scoliosis is the preservation of the normal architecture of the vertebrae and the lack of rotation. The curves are movable and temporarily correctable. When the cause that causes them is gone, the spine is fully restored, as long as no permanent changes have been created[3].

Primary or progressive structural scoliosis stands out as the most prevalent form of scoliosis, characterized by both lateral curvature and rotational misalignment of the spine. This variant impacts the structural integrity of the spine and is generally deemed irreversible unless appropriate treatment is administered.Subtypes of structural scoliosis include[4]:

a) Idiopathic scoliosis. It is the most common of all scoliosis (80%) and its etiology remains unknown. Today when we refer to the condition scoliosis, we mean idiopathic.
b) Congenital scoliosis. It is due to anomalies of the scoliosis such as congenital hemivertebra, synostosis of vertebrae from one side, synostosis of ribs, etc. It is usually of moderate severity, but in rare cases it can develop into a severe form of scoliosis.
c) Neuromuscular or paralytic scoliosis. It is the result of a disturbance in the balance of the muscles of the trunk by paralysis that affects one side or is greater than that. This category includes scoliosis from poliomyelitis, cerebral palsy and muscular dystrophy.
d) Degenerative scoliosis. It encompasses a lateral curvature of the spine induced by the degeneration of facet joints and intervertebral discs, which serve as the mobile components of the spine. This degenerative process and subsequent spinal asymmetry can develop gradually as an individual ages. Importantly, this form of scoliosis differs significantly from the typical adolescent-onset scoliosis in its causative factors.

The authors have no conflict of interest.

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Edited by: *Konstantinos Stathopoulos*

Accepted *30 January 2024*

Scoliosis in children

Scoliosis that occurs in children and adolescents refers to the condition in which the spine bends abnormally sideways, or rotates, and the degree of severity varies from mild to severe. When viewed from the side, there is a slight rounding (kyphosis) in the upper back and a sway (lordosis) in the lower back[5].

There are several types of childhood scoliosis. In some cases, spinal problems can develop even before the baby is born. Scoliosis can also often accompany a neuromuscular condition, such as muscular dystrophy or cerebral palsy.

Idiopathic scoliosis, which cannot be attributed to specific causes, is the most common form of scoliosis. Physiologically, idiopathic scoliosis in children and adolescents can be described as lateral and rotational curvature of the spine in the absence of associated congenital or neurological abnormalities. Mild scoliosis may require only regular medical monitoring; however, in more severe cases, braces or even surgery may be necessary[6].

Idiopathic scoliosis is mainly found in adolescents aged 10 to fully developed skeletal structures, but it can also be diagnosed in younger children or even infants. Idiopathic scoliosis can occur in both boys and girls, with girls being more prone to it. Additionally, girls are more prone to develop larger curves that require some form of intervention. It is estimated that the prevalence of idiopathic scoliosis is 2% of the world's adolescent population, with a spinal curve greater than 10° [7].

Estimates indicate that the prevalence ranges from 0.47% to 5.2% for children and adolescents suffering from idiopathic scoliosis worldwide.

Specifically, the occurrence of spinal curves with greater Cobb angles is significantly more pronounced in girls compared to boys. The female-to-male ratio escalates from 1.4:1 for curves ranging from 10° to 20° to 7.2:1 for curves exceeding 40°. The configuration of the curve and the prevalence of scoliosis are influenced not only by gender but also by genetic factors and the age at which it initiates[8].

Causes, symptoms and diagnosis

The etiology of scoliosis has been a field of expert research since the beginning of the twentieth century. A major development in research occurred in the 80s, with the development of imaging technology (CT and MRI). Since there are different types of scoliosis, the causes are correspondingly many and varied. According to NHS, 80% of cases of scoliosis have no known cause and are thus characterized as idiopathic. Some scoliosis are due to abnormal development during the fetal period of the spinal axis and are called 'congenital scoliosis', while others are the result of an accident or some disease.

Scoliosis can be categorized based on its origin: idiopathic, congenital, or neuromuscular. Congenital scoliosis stems from the embryological malformation of one or more vertebrae and can manifest in any part of the spine. Neuromuscular scoliosis is associated with neurological or muscular disorders. Idiopathic scoliosis is diagnosed when other causes are ruled out, constituting approximately 80 percent of all cases. Adolescent idiopathic scoliosis, typically identified during puberty, stands out as the most prevalent form of scoliosis[2].

As far as the symptoms of scoliosis are concerned, one or both hips exhibit elevation or an abnormal height. Rib cages are at varying heights. Changes in the appearance or texture of the skin over the spine, such as dimples, hairy patches, or color abnormalities, may occur. The entire body leans to one side, the waist appears uneven, and the head is not centrally aligned above the pelvis. Additionally, shoulders may display asymmetry, with one or both shoulder blades protruding[2].

Scoliosis is typically confirmed through various diagnostic methods, including a physical examination, X-ray, spinal radiograph, CT scan, or MRI. The Cobb Method is employed to measure the curve, and its severity is diagnosed based on the number of degrees. A positive scoliosis diagnosis is established when a coronal curvature, measured on a posterior-anterior radiograph, exceeds 10 degrees. Generally, a curve is deemed significant if it surpasses 25 to 30 degrees, while curves exceeding 45 to 50 degrees are categorized as severe and often necessitate more aggressive treatment.

A commonly used examination for preliminary assessment, particularly in pediatric and school screenings, is the Adam's Forward Bend Test. In this test, the patient bends forward at the waist, with feet together, at a 90-degree angle. This position allows the examiner to easily detect any trunk asymmetry or abnormal spinal curvatures. While this test serves as a simple initial screening tool to identify potential issues, it cannot precisely determine the type or severity of the deformity. Accurate and positive diagnosis requires radiographic tests[2].

School screening

Adolescent idiopathic scoliosis stands as the most prevalent type of scoliosis among children and adolescents. Statistically, it is reported that 2% to 4% of adolescents experience idiopathic scoliosis[9].

While not all adolescents will exhibit clinical symptoms, scoliosis has the potential to lead to rib deformities and respiratory challenges. Additionally, it may result in cosmetic issues and emotional distress[9]. The early and timely diagnosis of scoliosis allows the control of the deformity and the initiation of appropriate treatment, which aims to reduce the possibility of invasive surgical intervention. Modern studies have proven that school screening programs for scoliosis have led many teenagers to treatments that inhibited or hindered the progression of scoliotic curves as well as reduced or even eliminated the possibility of the need for invasive surgical treatment[10].

In 2004, the United States discontinued school

screening programs for scoliosis, citing concerns about cost-effectiveness and the potential unnecessary exposure of students to radiation for diagnostic confirmation or refutation within such programs. This decision followed a proposal by the U.S. Preventive Services Task Force and the American Academy of Family Physicians[10]. Nevertheless, several other organizations, including the American Academy of Orthopedic Surgeons, the American Academy of Pediatrics, the Scoliosis Research Society, and the Orthopedic Society of North America, have advocated for the reinstatement of scoliosis screening programs in schools. They argue that the benefits outweigh the drawbacks and emphasize the importance of careful selection of individuals with positive scoliosis screening results for further examinations[9].In general, there are various tools used in school screening programs to diagnose scoliosis in children and adolescents. These include the forward bending test, the forward bending test with scoliometry, the Moiré topography and the humpometer, with each of the mentioned diagnostic tools having a different degree of sensitivity and specificity[10].

Literature review

Fong et al[11] conducted a meta-analysis of published studies on the effectiveness of school-based screening for scoliosis. Data were collected from Google Scholar, PubMed and CINAHL databases. A total of 36 studies were examined that met the criteria (which related to the method of analysis, the method of examination, the age of the research participants, etc.), out of the 775 that were initially identified. There was high heterogeneity between the reviewed studies in relation to the screening tests used and also to the sample size. In the cases where the forward bending test was used as the only examination tool a higher referral rate and a lower precision in detecting scoliosis curves was detected. Therefore, the use of the forward bending test is inadequate for screening adolescents at school. In addition, the researchers noted that only one small study was long enough to track and record even the skeletal maturity of adolescents. The researchers note that more studies are needed which will be conducted for longer periods of time and will follow the research participants until their skeletal maturity.

School screening for scoliosis in Turkey was considered an issue that requires further study by Cilli et al[12]. The researchers examined 3,175 students aged 10 to 15 years with forward bend testing and palpation of the spine. In total, it was found that 0.47% of the children had scoliosis. The follow-up program lasting 2 years after the first examination did not detect any progression in curvature. The researchers concluded that routine school screening is still debatable.

In 2019, the US Preventive Services Task Force[13] conducted a study to assess the advantages and disadvantages of school screening programs for adolescent idiopathic scoliosis. According to their findings, insufficient evidence was available regarding the health outcomes and potential harms associated with screening in schoolchildren. Specifically, there was a lack of evidence to support the effectiveness of surgical or exercise interventions, while bracing was suggested to potentially delay curvature progression. Additionally, there was insufficient evidence linking delayed spinal curvature with long-term health outcomes in adulthood. The US Preventive Services Task Force concluded that there was also inadequate evidence to establish an association between scoliosis screening and potential risks. In summary, there is insufficient evidence to definitively determine whether the benefits of scoliosis school screening programs outweigh potential harms in adolescents.

In their study, Luk et al[14] investigated the efficacy of school scoliosis screening programs in Hong Kong. A total of 157,444 students meeting the study criteria were examined. In the initial phase, students underwent a forward bending test and angle of trunk rotation assessment. Those displaying evidence of adolescent idiopathic scoliosis or an angle of trunk rotation between 5 and 14 degrees then underwent routine moiré topography. Students with an angle of trunk rotation greater than 15 or more than 2 moiré lines were subjected to radiography and Cobb angle measurement. The results indicated that 2.8% of students were referred for radiography. In the final follow-up, positive predictive values were 9.4% for students requiring treatment and 43.6% for those with a Cobb angle equal to or greater than 20 degrees. The sensitivities were 80% and 88.1%, respectively. The researchers concluded that school screening programs in Hong Kong accurately predict cases of adolescent idiopathic scoliosis with high precision, coupled with a low referral rate.

The effectiveness of school screening programs for scoliosis is also pointed out by Grivas, Vasiliadis & O'Brien[15], who also state that this is well documented in the international literature. There is now sufficient evidence, as they note, that timely and early diagnosis of scoliosis through school screening programs can lead to a reduction in the likelihood of surgery in the future. In their article, the researchers mention some modifications, which can further increase the effectiveness of such programs. These modifications concern the organization, the optimal position for examination, the appropriate age for screening, the standardization of the referral process for further examination, follow-up programs and the reduction of financial costs.

Kuroki et al[16] collected data from the last 33 years on the effectiveness of school screening programs for scoliosis using Moiré topography in Japan. A total of 689, 293 male and female students were examined from 1981 to 2013 in order to record the students to whom a screening program was applied at school, the positive results from Moiré topography, the referral rate to the second screening, the positive predictive values, and the diagnostic values scoliosis greater than 20°. The results of the research showed that the school screening programs for detecting scoliosis using Moiré topography are effective, although the positive predictive values and the reference rate are low.

Similar findings were reported in the study by Scaturro et al[17], which aimed to assess the effectiveness of school screening programs in diagnosing adolescent idiopathic scoliosis. The study involved three different tests - Adam's test, axial trunk rotation, and plumb line. If at least one of these tests yielded positive results, an X-ray examination was recommended. The researchers concluded that school screening programs for scoliosis detection demonstrated a very high specificity.

In the study conducted by Deepak et al[18], the primary objective was to evaluate the clinical effectiveness of school screening programs for adolescent idiopathic scoliosis in Malaysia. The researchers examined 8,966 students aged 13 to 15, utilizing the forward bending test and the angle of trunk rotation as examination tools. Students with positive test results underwent standard radiographs to measure the Cobb angle. The study found that 2.5% of the students were diagnosed with scoliosis. The referral rate for radiography was 4.2% for boys and 5% for girls, with a positive predictive value of 55.8%. These results led the researchers to conclude that school screening indeed facilitated early detection of scoliosis.

Kapoor, Laham & Sawyer[19] explored ways to enhance the effectiveness of school screening programs for scoliosis detection. They specifically proposed that incorporating simple measurements such as height and weight, along with utilizing research tools like questionnaires, could positively impact the overall efficacy of these programs. The survey involved 1,058 students, with 30 (2.8%) identified with scoliosis. Among the participants, 284 students (27%) were found to be overweight, and 468 (44%) were either overweight or at risk. Additionally, 646 students (61%) did not have an identified healthcare provider. The researchers concluded that, even if the accuracy of scoliosis screening remained unchanged, the number of students at risk for significant health problems increased significantly.

The researcher Thilagaratnam[20] attempted to answer the question of whether school screening programs for adolescent idiopathic scoliosis are cost effective. More specifically, Thilagaratnam conducted a study comparing cases where school screening programs for scoliosis with a follow up program were implemented versus cases where such programs were not implemented. The aim was to examine whether such programs enable early curvature detection which then leads to bracing initiation and the reduction or even elimination of the possibility of the need for surgery. In the study, it was hypothesized that in the absence of scoliosis school screening programs, students who ultimately received bracing would have needed to undergo surgery. The study sample consisted of 45,485 students in the year 1999 and 44,051 students in the year 2001. Considering the economic costs and health outcomes of school screening for scoliosis programs, the researcher concluded that the implementation of such programs in Singapore is cost effective, while he suggested that the cost effectiveness may be further improved through small modifications, such as the targeting of specific groups, e.g. prepubertal females. However, the researcher noted that further research is needed to quantify the positive health outcomes of school screening programs for adolescent idiopathic scoliosis.

Similar conclusions were reached in the study by Sabirin et al[21], which aimed to examine the effectiveness and cost-effectiveness of school scoliosis screening programs. The researchers collected 248 relevant titles, of which 117 abstracts were examined and finally 28 articles were included in the analysis. There was sufficient evidence that such programs are safe and contribute to the early diagnosis of scoliosis, thereby reducing the likelihood of the need for surgery. Furthermore, the analysis showed that these programs are cost effective. The researchers concluded that school screening programs are effective and cost effective, especially if they are aimed at high risk populations, such as girls at the age of twelve.

Ugras et al[22] examined the cost effectiveness of the school screening programs for scoliosis in Turkey. Their research sample consisted of 4,259 students, of which 2,057 were girls and 2,022 were boys. All the students were between 10 and 14 years old. It was found that 2.5% of the examined students had scoliosis. For every 10 boys diagnosed with scoliosis, 25 girls were also diagnosed. A minor curve, that is a Cobb angle smaller than 20o, was found in the 72.7% of the tested cases, while a major curve, that is a Cobb angle greater than 20°, was found in 27,3% cases. Regarding the costs, the examination for each child amounts to 47 cents, while the cost for each case of diagnosed scoliosis amounts to $236.81, leading the researchers to the conclusion that scoliosis screening in Turkish schools is cost effective.

Discussion

From the review of the literature, it seems that there is no consensus regarding the effectiveness of school screening programs for adolescent idiopathic scoliosis. The debate revolves around whether the benefits obtained from such programs outweigh the harms and disadvantages. The benefits relate to the early diagnosis of adolescent idiopathic scoliosis which will lead to fewer interventions and treatment during the person's lifetime. On the other hand, it is supported by several scholars that such programs have a high referral rate, subjecting students to interventions and examinations that are not necessary. It is also a question whether these programs are ultimately cost effective. The purpose of this paper was to examine the international literature, to record the current trends around the issue of school screening programs for adolescent idiopathic scoliosis and to draw a conclusion on whether it is ultimately safe to assume that scoliosis school screening programs are effective and they should be applied universally.

Fong et al[11] conducted a meta-analysis of published studies to examine the effectiveness of school screening

programs for adolescent idiopathic scoliosis. No clear conclusions emerged from the review of studies, which showed high heterogeneity. The researchers noted that further research is needed to examine the effectiveness of such programs, as well as research that will follow patients up to their skeletal maturity for safer conclusions. Similar results were reached by Cilli et al[12], but also the US Preventive Services Task Force[13], stating that there cannot be a clear conclusion regarding the overall effectiveness of scoliosis school screening programs.

Although several studies suggest further research on the subject, it seems that the majority of the international literature agrees on the effectiveness of these programs, especially if there are small modifications that will additionally increase effectiveness and cost effectiveness. This is what the scholars Grivas, Vasiliadis & O'Brien[15] proposed, according to which, small differences regarding the age of the examinees, the referral process, the follow up programs, etc. can increase the effectiveness and cost effectiveness of such programs. Similar findings were obtained from the study by Sabirin et al.[21], Kapoor, Laham & Sawyer[19] and Thilagaratnam[20]; according to the latter, school screening programs in Singapore are cost effective, but the cost effectiveness can be further improved through small modifications.

There is a large part of the literature that states that the examined school screening programs for idiopathic scoliosis were effective, without mentioning that further modifications were needed. These are the results that the studies of Luk et al[14], Kuroki et al[16], Scaturro et al[17], Deepak et al[18] and Ugras et al[22] presented.

Conclusion

In conclusion, it can be safely concluded that the school screening programs for adolescent idiopathic scoliosis can be characterized as effective, and also cost effective, especially if certain modifications are made regarding the examination method, the sample examined, the referral process, the follow up programs etc. Several studies were examined and no study was found that clearly stated that school screening programs for idiopathic scoliosis are not effective and/or cost effective.

References

1. Illés T, Tunyogi-Csapó M, Somoskeöy S. Breakthrough in three-dimensional scoliosis diagnosis: significance of horizontal plane view and vertebra vectors. European Spine Journal 2011;20(1):135-143.
2. American Association of Neurological Surgeons. Scoliosis 2023.
3. Scoliosis Research Society. Scoliosis 2023.
4. Baaj A. Types of Scoliosis. Spine-Health 2017.
5. Calloni SF, Huisman TA, Poretti A, Soares BP. Back pain and scoliosis in children: When to image, what to consider. Neuroradiol J 2017;30(5):393-404.
6. Giampietro PF, Blank RD, Raggio CL, Merchant S, Jacobsen FS, Faciszewski T, Skukla SK, Greenlee AR, Reynolds C, Schowalter DB. Congenital and idiopathic scoliosis: Clinical and genetic aspects. Clinical Medicine and research 2003;1(2):125-136.
7. Soucacos PK. School screening for scoliosis, the Greek experience. Scoliosis 2010;5(1).
8. Konieczny MR, Senyurt H, Krauspe R. Epidemiology of adolescent idiopathic scoliosis. J Child Orthop 2013;7(1):3-9.
9. Horne JP, Flannery R, Usman S. Adolescent idiopathic scoliosis: Diagnosis and management. American Family Physician 2014; 89(3):193-198.
10. Matthew O, Heyer J, Shannon, M. Scoliosis screening. Journal of the American Academy of Orthopaedic Surgeons 2021;29(9):370-379.
11. Fong DYT, Cheung KMC, Cheng JCY, Ng BKW, Ping T, Mak KH, Yip PSF, Luk KD. A meta-analysis of the clinical effectiveness of school scoliosis screening 2010;35(1):1061-1071.
12. Cilli K, Tezeren G, Tas T, Bulut O, Oztürk H, Oztemur Z, Unsaldi T. Acta Orthopaedica et Traumatologica Turcica 2009;43(5);426-430.
13. Us Preventive Task Force. Screening for adolescent idiopathic scoliosis: US Preventive Services Task Force recommendation statement. JAMA 2018;319(2):1650172.
14. Luk KDK, Lee CF, Cheung KMC, Cheng JCY, Ng BKW, Lam TP, MAk KH, Yip PSF, Fong DYT. Clinical effectiveness of school screening for adolescent idiopathic scoliosis: A large population-based retrospective cohort study. Spine 2010;35(17):1607-1614.
15. Grivas TB, Vasiliadis ES, O'brien JP. Suggestions for improvement of school screening for idiopathic scoliosis. Studies in Healthy Technology and Informatics 2008;140:245-248.
16. Kuroki H, Nagai T, Chosa E, Tajima N. School scoliosis screening by Moiré topography - Overview for 33 years in Miyazaki Japan. J Orthop Sci 2018;23(4):609-613.
17. Scatturo D, de Sire A, Terrana P, Costantino C, Lauricella L, Sannasardo CE, Vitale F, Mauro GL. Adolescent idiopathic scoliosis screening: Could a school-based assessment protocol be useful for an early diagnosis? Journal of Back and Musculoskeletal Rehabilitation 2021;34(2):301-306.
18. Deepakn AS, Ong, JY, Choon D, Lee CK, Chiu CK, Chan C, Kwan MK. The clinical effectiveness of school screening program for idiopathic scoliosis in Malaysia. Malaysian Orthopaedic Journal 2017;11(1):41-46.
19. Kapoor M, Laham SG, Sawyer J R. Children at risk identified in an urban scoliosis school screening program: A new model. Journal of Pediatric Orthopedics 2008;17(6):281-287.
20. Thilagaratnam S. School-based screening for scoliosis: is it cost-effective?. Singapore Med J 2007;48(11):1012-1017.
21. Sabirin J, Bakri R, Buang SN, Abdullah, AT, Shapie A. School scoliosis screening program – a systematic review. The Medical Journal of Malaysia 2010;65(4):261-267.
22. Ugras AA, Yilmaz M, Sungur I, Kaya I, Koyuncu Y, Cetinus ME. Prevalence of scoliosis and cost-effectiveness of screening in schools in Turkey. Journal of Back and Musculoskeletal Rehabilitation 2010;23(1):45-48.