

School Scoliosis Screening - World Trends and the Problems Encountered in Japan

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Conflict-of-interest statement: The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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Received: September 11, 2017

Revised: September 16, 2017

Accepted: September 17 2017

Published online: October 28, 2017

ABSTRACT

School scoliosis screening (SSS) was initiated in the United States in the 1960s and adopted across the world thereafter. In Japan, SSS was implemented gradually in the 1980s after being enshrined into law in 1978. This editorial article summarizes the world trend of SSS through a comprehensive literature review. Future development of SSS is also described based on analysis of its current status and issues related to SSS in Japan.

Key words: School scoliosis screening; Moiré topography; Forward bending test; Scoliometer; School musculoskeletal screening

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Kuroki H. School Scoliosis Screening - World Trends and the Problems Encountered in Japan. *International Journal of Orthopaedics* 2017; 4(5): 814-818 Available from: URL: <http://www.ghrnet.org/index.php/ijdo/article/view/2138>

INTRODUCTION

Adolescent idiopathic scoliosis (AIS) is a complex three dimensional developmental deformity of the spinal column and associated rib cage characterized by a lateral deviation and axial rotation^[1,2,3]. The diagnostic criterion is a lateral curvature of the spine measuring at least 10° on an X-ray as determined by the Cobb method^[4]. The prevalence rate of AIS, using a cut-off point of 10° or more, is approximately 2-2.5%^[5,6]. Untreated cases of AIS may progress, and severe cases are at increased risk for various morbidity problems and mortality^[7]. Although several procedures for operative and non-operative treatment of AIS have evolved, the most effective treatment is still based on early detection. In this regard, school scoliosis screening (SSS) is a powerful tool that can be used to identify children who may have deformity as well as those who may be at high risk for the disease^[8].

SSS has been established as a valuable method for early detection of the disease and prophylaxis for severe deformity^[9,10]. SSS has been practiced widely in the United States (US) and throughout the world for nearly 60 years^[4]. The goal of SSS is to detect scoliosis at an early stage when deformity is likely to go unnoticed and when there is an opportunity for a less invasive method of treatment, or less surgery, than would otherwise be the case^[4,11,12].

The aim of this editorial column is to summarize the contribution of SSS and to provide some useful suggestions for the improvement of the screening process, by reviewing all scientific papers derived from previous SSS programs.

HISTORY OF SSS

In the US, medical experts who researched posture in the first decades of the 20th century believed that poor bodily comportment was not only a sign of disease but also a causative factor of ill

health. In 1915, Bancroft advocated school posture evaluations and founded the American Posture League in 1914 to assist in both the surveillance and the maintenance of proper posture among the nation's youngest citizens^[13]. In 1947, the earliest screening program for spine deformities was established to identify curvatures due to the residual effects of the poliomyelitis epidemic in Minnesota^[10].

MacEwen played an important role in the early development of SSS by implementing programs in all schools in the state of Delaware in the 1960s^[4,14]. In 1962, his colleagues led by Shands, modified existing school posture examinations, transforming them into spinal screenings for idiopathic scoliosis^[13]. SSS officially began in 1963 in Aitken, a town with a population of about 10,000 in central Minnesota, utilizing the forward bending test (FBT)^[10,14].

After that, the model for SSS spread around the world via the published works of Kane, Lonstein and Winer, and Moe^[15].

SSS PROCEDURES

Several techniques have been described for the early detection of spinal deformities. The most popular is the FBT developed by Adams in 1865^[16], followed by rib-hump measurement with a scoliometer^[17] and a three dimensional description of the shape of the trunk using the Moiré topography^[18].

The FBT is the most commonly applied screening test for scoliosis, as it is quick, cheap, and easy to perform. However, the FBT leads to a large number of false-positive results and is not sufficient for accurate screening when used alone^[7]. Therefore, the widespread use of SSS with the FBT must be questioned and cannot be considered a diagnostic criterion^[19,20].

To quantify findings from the FBT and to measure the angle of trunk rotation (ATR), a specially designed inclinometer was introduced as a scoliometer^[17]. The ATR and the Cobb angle were found to be well correlated^[21].

The value of the Moiré topography, as a non-invasive screening technique with limited radiation exposure, depends on its accuracy in showing the location and the magnitude of a curve. However, the Moiré topography requires expensive equipment and has a high rate of false-positive results^[11].

For these circumstances, Grivas *et al*^[14] insisted that the solution is the use of a scoliometer for the performance of SSS. Additionally, Labelle *et al*^[22] published an information statement by the Scoliosis Research Society (SRS) international task force stating that a scoliometer is currently the best tool available for SSS.

POSITION ON SSS

To date, the efficacy of SSS has not been established sufficiently because of a lack of randomized, controlled trials. Some studies concluded that SSS is effective, whereas others questioned the effectiveness or even considered such screening to be unethical^[23]. Arguments against screening are as follows: (1) low predictive value leading to excessive number of children referred to specialists; (2) possibly increased amount of x-ray imaging in children; (3) lack of certainty about which instance of small scoliosis (Cobb angle < 20°) will progress and require treatment; (4) cost issue and (5) stress induced by examination^[6].

Further, in the past, the value of SSS has been debated due in part to inconclusive evidence of the success of non-operative treatment for scoliosis. However, this is no longer true as evidence from the BraiST study^[24] established the effectiveness of bracing as early, non-operative care that can reduce the number of patients that progress to surgery^[25]. With the results of the BraiST multicenter

NIH trial, there is level I evidence to support the efficacy of brace treatment in AIS^[22]. Further, in 2016, Karol *et al*^[26] reported the results of brace treatment with compliance monitoring. Compliance counseling based on sensor data increased brace use by an average of 3.2 hours daily and decreased the number of patients that require surgery by 11%. The authors advocated the inclusion of compliance monitoring /counseling as part of the clinical care of patients of any age wearing an orthosis for idiopathic scoliosis^[26].

In 2013, the SRS international task force began pursuing a consensus based on careful analysis of a recent critical review work of the literature on SSS, performed using a conceptual framework of analysis focusing on five main dimensions: technical, clinical, program, cost, and treatment effectiveness. They concluded that there is moderate evidence that SSS allows for the detection and referral of patients at an earlier stage of the clinical course, and that there is low evidence suggesting that scoliosis patients detected by screening are less likely to need surgery than those who did not undergo screening^[22].

In the near future, the global position on SSS is expected to be standardized and organized in accordance with the accumulation of supporting evidence regarding these concepts.

STATUS OF SSS IN THE WORLD

The first SSS was conducted by McEwen and Shands in Delaware, US in the 1960s as mentioned before^[15]. The United States Preventive Services Task Force (USPSTF) initially released an opinion on SSS in 1996 stating that there was insufficient evidence to make a recommendation for or against routine SSS^[27]. However, in 2004, they changed their position and recommended against the routine screening of asymptomatic adolescents for idiopathic scoliosis^[28]. In contrast, in 2008, the American Academy of Orthopaedic Surgeons (AAOS), the SRS, the Pediatric Orthopaedic Society of North America (POSNA), and the American Academy of Pediatrics (AAP) issued an information statement indicating that they did not support any recommendations against SSS, given the available literature. Despite mounting evidence throughout the 1990s that SSS was ineffective, costly, and potentially harmful psychologically, more and more US states instituted SSS^[13]. By 2003, 21 states had legislated SSS, 11 states recommended SSS without legislation and the remaining states either had volunteer screening or recommended the avoidance of screening in schools^[14]. In 1989, Asher *et al*^[29] reported a large difference among SSS programs and activities in North America based on the results of a survey by mailed questionnaire regarding the status of SSS. They subsequently introduced some recommended changes for SSS programs including statewide uniformity within a program.

In the 1970s, SSS programs were implemented in Canada, and all children of grades 6 and 7 (age, 10-14 years) were to be seen by a trained nurse for a back examination using the FBT. Since 1979, however, SSS program were progressively discontinued mainly because they were not considered cost-effective by the Canadian Task Force on the Pediatric Health Examination^[30]. Eventually, Canada officially brought its nationwide screening program to an end in 2003 because evidence showed that many treatments were ineffective^[13].

The British Orthopaedic Association (BOA) and the British Scoliosis Society (BSS) recommend against the implementation of screening programs in the United Kingdom at the national level^[31-33].

The Australian National Health and Medical Research Council (NHMRC) recommends against SSS, as, despite the accessibility

of comparatively cheap screening tests for idiopathic scoliosis, there is no convincing evidence indicating that they are beneficial and, furthermore, sufficient evidence against screening is available and existing therapies are not beneficial for mild and moderate deformities^[33]. However, to resolve the matter, Australia introduced a “National Self-Detection Program for Scoliosis”, urging a more autonomous approach to care by having adolescents and their families seek out spinal examinations from their primary care physicians^[13].

Bunge *et al*^[23] performed a case-control study estimating the effectiveness of SSS in the Netherlands. Their results showed no evidence that SSS using the FBT reduced the need for surgery. Therefore, they concluded that abolishing SSS was justified.

In Norway, SSS was conducted during the 1970s and 1980s. However, Norway abolished SSS in 1994 based on the USPSTF recommendations^[2,34].

In 1977, a conventional screening program was introduced in Sweden, involving annual mandatory screening of all school children between the ages of 7 and 16^[35]. The FBT was always used, and a specially trained nurse assisted in the screening. Sweden is the only Scandinavian country with an ongoing SSS^[2,34].

Soucasos *et al*^[8] reported the results of SSS using the FBT in northwestern and central Greece. They concluded that SSS appears to be an effective method for the early detection and non-operative treatment of scoliosis and generates invaluable data regarding not only the prevalence but also the natural history of spinal deformities.

In Denmark, pre-adolescent children are primarily screened for scoliosis by school doctors and nurses using the FBT. After the Moiré topography was introduced, it revealed twice as many cases of scoliosis as did conventional clinical screening, despite many false positive results^[36]. However, no specific SSS programs have been successfully implicated^[34].

The Polish Agency for Health Technology Assessment evaluated and did not recommend the implementation of a regional program for the prevention of posture deformities in children^[33].

Goldberg *et al*^[37] reported the results of SSS in Dublin Ireland, and concluded that the prime objective of the program has not been achieved although the implementation of SSS since 1979 has contributed greatly to the perception and understanding of AIS.

In Hong Kong, a SSS program that used the FBT, the ATR measured by a scoliometer, and the Moiré topography has been implemented since 1995^[38]. Continuation of the Hong Kong SSS program was recommended because 88.1% and 80.0% of adolescents who had a Cobb angle $\geq 20^\circ$ and required treatment for scoliosis, respectively were detected by the SSS^[39].

In other countries, SSS programs are compulsory or are provided on a voluntary basis in China, Bulgaria, Spain, and Israel, and also, Singapore, Italy, Turkey, and Malaysia^[33].

STATUS OF SSS IN JAPAN

In Japan, SSS is mandated by law^[14]. Revision of the law on school health in 1979 facilitated the implementation of SSS. However, the actual implementation depends on local educational committees, that is, both the age of the subjects and the screening methods are different from region to region. In addition, SSS is not conducted in all areas. In 2007, Tajima *et al*^[40] reported the results of a questionnaire survey about SSS from the members of the Japanese Scoliosis Society. Twenty nine percent of members implemented SSS, while 63% of members did not. The FBT and the measurement of ATR with a scoliometer are readily employed in

some communities as the primary screening method while other areas primarily use the Moiré topography for students in specific grades. In the Hiroshima prefecture, the Silhouetter system, which is similar to the Moiré topography, was first introduced^[41]. The students with positive judgment in the primary screening are referred to a second screening using radiography. However, future SSS using the Moiré topography was discontinued due to recent cessation of the repair and production of Moiré topographic equipment. AS an alternative, compulsory school musculoskeletal screening (SMS) was initiated in 2016. Since SMS includes an evaluation of the spine through inspection by school doctors, school screening specific to scoliosis will finish in the near future.

DIRECTION OF SSS IN JAPAN

SSS in Japan is currently at a turning point. SSS using the Moiré topography seems to be successful in detecting scoliosis despite the low positive prediction value. Hereafter, reestablishment of SSS must be accomplished using SMS instead of traditional screening with the Moiré topography.

The detection of scoliosis by using SMS at a level comparable to previous SSS is extremely crucial. Spinal deformity is assessed by school doctors through SMS with the FBT alone for students who are fully dressed. However, SRS insists that the scoliometer is currently the best tool available for SSS because the FBT results in an unacceptable number of false-negative results. The use of a scoliometer can surely make objective evaluation of trunk rotation possible. Further, screening with a scoliometer is not only cheaper but also has the same or better accuracy than that with Moiré topographic equipment. However, the burden on the screeners is greater because direct examination is necessary. In the next couple of years, the results of SMS, as well as cost-effectiveness, will be analyzed in detail, and should be refined to reduce false-positive and false-negative results.

Some Japanese doctors are currently trying to develop new instruments for SSS utilizing information technology (IT). Ueno *et al*^[42] introduced a smartphone application designed to create a cheaper, simpler, and more widely available screening system for scoliosis. This system enables users to photograph and transmit images of the back at home. If SMS has some limitations in detecting scoliosis, an original SSS program that is not only standardized nationally but also economically effective should be independently constructed by popularizing the existing Silhouetter system or adopting a novel screening system using IT.

In addition, the contents of the screening program should be reconsidered. The selection of the subject per se and the alteration of judgment criteria, depending on the sex or maturation of the subjects, may be preferable to increase the accuracy of the program and lighten the burden on the screeners. The SRS international task force stated that females should be screened twice, at ages 10 and 12, and boys should be screened once, at age 13 or 14. In addition, there is moderate evidence to recommend referral with scoliometer values greater than 5° .

Further, activities awareness promoting of scoliosis for the general public are indispensable. Dissemination of accurate knowledge about the importance of SSS can reduce the number of individual opposed to receiving SSS and consequently improve the scoliosis discovery rate at an early stage. Distribution of brochures about scoliosis is also a valid and feasible option.

In the future, an optimal SSS program should be designed based on these factors for the management of scoliosis.

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