Adolescent School Screening for Scoliosis in Minnesota

Review of Literature and Current Practice Recommendations

A Working Document

Minnesota Department of Health
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I. Introduction

This document reviews of current research and data, trends, and technology for the purpose of updating the Minnesota Department of Health (MDH) **Adolescent School Scoliosis Screening** recommendations and best practices. This review is being conducted in accordance with the MDH's Maternal and Child Health Section mission to provide statewide leadership and public health information essential for promoting, improving or maintaining the health and well-being of women, children and families throughout Minnesota. To accomplish this mission, we periodically review our well-child screening practice recommendations in such topics as hearing, vision, oral/dental, developmental, and so on. Our reviews take into consideration current research, screening resources at the state and local level as well as feedback from public and private providers, parents, researchers and other key stakeholders.

The review begins with adolescent scoliosis: its etiology, risk factors, and prevalence. Further discussions include school screening programs, available screening tools, referral, and cost-effectiveness of screening programs. Additionally, recommendations by professional organizations and literature sources are provided. The review concludes with the next step: key issues to be addressed by the MDH Scoliosis School Screening Workgroup

II. Adolescent Scoliosis

Overview of Scoliosis:

Scoliosis is a three-dimensional deformity of the spine (Huang, 1997), characterized by both vertebral and trunk rotation (Bunnell, 2005). Individuals with scoliosis may exhibit markedly altered standing postures and rib cage deformity. There may be only one curve, or a primary curve with a compensatory second curve (Pearsall *et al.*, 1992).

Idiopathic scoliosis, which has no known cause, is the most common cause of curvature of the spine and is divided into three age groups. Infantile idiopathic scoliosis is detected before age three. Juvenile idiopathic scoliosis is detected between the ages of three and ten (Rooney and Akbarnia, 2004) or up to the onset of puberty (Lonstein, 1988). Adolescent idiopathic scoliosis occurs between the onset of puberty and skeletal, or physiologic, maturity (Gunnoe, 1990). Adolescent idiopathic scoliosis is the most common subcategory of idiopathic scoliosis (Rooney and Akbarnia, 2004) and is the primary subject of this review.

The gold standard for assessing scoliosis is using radiography to determine a Cobb angle. The Cobb angle measures degree of a scoliosis curve by the least number of vertebrae that produce the maximum degree of angulation or curvature of the spine. See page 8 for more information on radiography and determination of the Cobb angle. Few children with curves less than a 20˚ Cobb angle are considered candidates for active treatment (Yawn and Yawn, 2000) and instead are monitored, unless the patient's bones are very immature and curve progression is likely (Greiner, 2002). Children with curves of 40˚ Cobb angles or more may be considered potential surgical candidates (Yawn and Yawn, 2000). Larger curves in younger patients tend to progress more, but to what degree and how soon has been difficult to predict precisely. As a rule, the greater the curve and the younger the patient, the greater the tendency for progression of the curve (Rooney and Akbarnia, 2004).

When scoliosis is not treated, the spine may undergo progressive axial rotation, increasing the clinical deformity (Gunnoe, 1990). This progressive axial rotation can lead to an

increased incidence and severity of back pain (Bunnell, 2005), progressive cosmetic deformities, social and psychological problems, and financial costs (Bunnell, 1984). With severe curvatures of more than 80˚ (Bunnell, 2005) or 100˚ (Greiner, 2002, and Bunnell, 1984), there can be cardiopulmonary compromise as well as subsequent morbidity and early mortality (Gunnoe, 1990).

Etiology

Idiopathic scoliosis has an unknown etiology despite extensive studies. The idiopathic diagnosis is given to a scoliosis case where there is an absence of other spinal malformation or functional abnormalities (Gunnoe, 1990). The causes of scoliosis are probably multiple (Staheli, 2001), involving neuromuscular, hormonal, biomechanical, and other abnormalities (Mirtz, Thompson, Greene, Wyatt, and Akagi, 2005).

There is a genetic component, but the mode of inheritance is uncertain (Staheli, 2001). One study showed a 73% phenotypic concordance of scoliosis in monozygotic twins (Greiner, 2002). There are three possible etiological theories; possible bone malformation during development, asymmetrical muscle weakness, and abnormal postural control because of possible dysfunction of the vestibular system (Mirtz *et al.*, 2005).

Risk Factors

The risk factors that can be identified prior to a screening include gender, age at diagnosis (Gunnoe, 1990), menarche, curve pattern, and growth potential. Females are at 3-10 times greater risk than males. Children younger than twelve years have three times the risk of progression, and the risk is reduced by two thirds after girls reach menarche (Bunnell, 2005). The most frequently used criteria is skeletal maturity (Rooney and Akbarnia, 2004). The growth potential is the greatest risk of progression (Bunnell, 2005). Also, as discussed in etiology, a family history of scoliosis is present in about 30% of kids with spinal curvatures (Killian, Mayberry, and Wilkinson, 1999).

Prevalence

The prevalence of scoliosis has also been a subject of much research and depends greatly upon the criteria for defining scoliosis. For curves greater than 5˚, Bunnell (2005) reports a prevalence of 7.7% and Rogala, Drummond, and Gurr (1978) reports an incidence of 0.45%. As the criteria for defining scoliosis uses larger curves, the prevalence decreases. For curves greater than 10˚, a range from 0.59% to 3% prevalence has been reported (Wong, Hui, Rajan, and Chia, 2005; Mirtz *et al.*, 2005; Yawn, Yawn, Hodge, Kurland, Shaughnessy, Illstrup, and Jacobsen , 1999; Nussinovitch, Finkelstein, Amir, Greenbaum, and Volovitz , 2002; Soucacaos, Zacharis, Soultanis, Gelalis, Xenakis, and Beris, 2000; Staheli, 2001). For curves greater than 20˚, a range from 0.244% to 0.7% prevalence has been reported (Soucacaos *et al.*, 2000; Torell, Nordwall, and Nachemson, 1981; Bunnell, 2005; Yawn *et al.*, 1999). For curves greater than 30˚, prevalences of 0.044% (Soucacaos *et al.*, 2000) and 0.2% (Bunnell, 2005, Staheli, 2001) were reported. And for curves greater than 40˚, 0.014% (Soucacaos *et al.*, 2000), 0.1% (Staheli, 2001, Bunnell, 2005, Goldberg, Dowling, Fogarty, and Moore, 1995), and 0.3% (Yawn *et al.*, 1999),

have been reported. Bunnell (1993) states that the risk of developing a curve that requires treatment is only 1/1000, or 0.1%.

As explained earlier, one risk factor for scoliosis is being female. Although Staheli (2001) found girls and boys to be equally affected, most studies agree that girls have a higher prevalence of scoliosis than boys (Wong *et al.*, 2005; Pruijs, Van Der Meer, Hageman, Keessen, and Van Wieringen, 1996; Nussinovitch *et al.*, 2002; Rogala *et al.*, 1978; Willner and Uden, 1982; Bunnell, 2005; Mirtz *et al.*, 2005; Soucacaos *et al.*, 2000; and Gore, Passehl, Sepic, and Dalton, 1981). Bunnell (2005) states that the prevalence is nearly equal in both genders for small curves, but for curves greater than 30˚, girls have a 3-10 times greater prevalence than boys. Mirtz *et al.* (2005) found that in curves less than 10˚, the ratio of girls to boys with scoliosis was 1.5 to 1, and continually increased as the curves got larger, with a ratio of 5.5 to 1 for curves 30-39˚, until decreasing to 1.2 to 1 for curves greater than or equal to 40˚.

As Wong *et al.* (2005) states, "prevalence rates of idiopathic scoliosis vary from 0.35% to 13%, depending on the defined Cobb angles, screening age, and sex." There are also regional (Ohtsuka *et al.*, 1988) and ethnic (Soucacos *et al.*, 1997) differences in the prevalence rate. For example, the study of Singapore children by Daruwalla *et al*. (1985) found that Chinese girls in Singapore had a significantly higher prevalence of adolescent idiopathic scoliosis than Malaysian and Indian girls.

III. Scoliosis Screening Programs

Screening Overview and Effectiveness

According to the American Commission on Chronic Illness, screening is the "presumptive identification of unrecognized disease or defect by the application of tests, examination, or other procedures which can be applied rapidly" (Wong *et al.*, 2005). Schools are considered the sites most likely to provide access to almost all children (Yawn and Yawn, 2000), and so school screening programs have been set up to detect scoliosis early when the deformity is likely to otherwise go unnoticed. In the early stages of scoliosis, there is still an opportunity for a less invasive treatment method. The main treatment concern for adolescents with scoliosis is preventing curve progression (Bunnell, 2005). The earlier that diagnosis and treatment for idiopathic scoliosis occurs, the better the outcome (Rooney and Akbarnia, 2004).

The principles of an effective screening program are that the condition screened is an important health problem and there is an asymptomatic phase of the disease during which screening is the only way to identify affected individuals. Also, there must be a simple test, an accepted benefit, effective treatment, and the benefits from treatment outweigh the costs of screening ("To Screen or Not to Screen?" 2000). This last condition, relating to cost-effectiveness, has been of great debate in regards to school scoliosis screening, and will be discussed in greater detail later. *For a summary of advantages and disadvantages of school screening programs, see Table 1, page 7.*

There have been several studies done on the long-term effect of scoliosis screening programs. In Minnesota, a study was done by Lonstein, Bjorklund, Wanninger, and Nelson (1982), comparing statistics of the prevalence of treatments required and sizes of spinal curves from 1970 to 1979-80. In 1973-1974, Minnesota began statewide school scoliosis screening. The number of children requiring active treatment decreased by 0.142% from 1974-1975, and decreased another 0.041% from 1979-1980. The average size of major curves decreased from 60˚ in 1971 to 42˚ in 1979. The average initial curve of patients referred to the Twin Cities

Scoliosis Center fell from 42˚ in 1970 to 22˚ in 1975. The percentage of patients being treated with braces fell from 51% to 7% in those same years, and the percentages of patients being treated through surgery fell from 28% to 3%.

Two similar studies were conducted in Sweden, the first by Torell *et al.* (1981), comparing data between 1968 through 1978. The incidence of curves greater than or equal to 40˚ decreased from 1.6/1000 in 1968 to 0.6/1000 in 1978. The mean curve also fell from 46˚±18˚ to 28˚±6.3˚. In 1968-1970, 32% of patients needed surgery when first seen at the referral. By 1978, only 12% of referred patients needed surgery after first seen. The other Sweden study, by Bremberg and Nilsson-Berggren (1986), compared data from two periods. The first period, 1972-1980 was when doctors performed the screenings on children in grades 1, 4, and 8 with no specific referral criteria. In the second period, from 1981-1983, nurses performed the screening using specific referral criteria. In the first period, 2.7% were referred, and the average curve was 28.7˚. In the second period, 1.2% were referred, and the average curve had decreased to 25.1˚.

Table 1: Summary of Advantages and Disadvantages of School Screening Programs

	Advantages	Disadvantages
Screen All Children Ages 10-15 Yearly	* Will catch most curves before they become severe and require treatment, saving children from related health problems	* Expensive * Time-consuming
Selectively Screen: (females, 10 & 12 years; males, 13 or 14 years)	* Can screen only the people at higher risk * Saves more time and money than screening everyone * Should still catch most curves early	* Still a possibility of missing a curve in a low-risk child who doesn't get screened * Costs more time and money than doing nothing
Don't Screen Any Children	* Saves time and money * Prevalence is low, so there are few cases to begin with	* Miss the opportunity to catch curves before they require bracing and surgery * Curves not caught can have serious detrimental effects to the child's physical and mental health

Outside of school screenings, additional opportunities for scoliosis screening exist. In **Bright Futures: Guidelines for Health Supervision of Infants, Children, and Adolescents 3rd edition,** the American Academy of Pediatrics recommends well-child visits yearly at ages 10 through 18 for males and females. A physical exam is part of the well-child visits and includes routine inspection of the back, with special attention to curvature during the adolescent growth spurt (Hagan, Shaw, and Duncan, 2008).

Screening Tools Available

The purpose of a scoliosis screening tool is to relate the observed external deformity to the internal severity of spinal distortion (Pearsall, Reid, and Hedden, 1992). Many tools have been developed, attempting to meet this criteria including Radiography, Adam's Forward-Bending Test, Scoliometer, Moire topography, Humpometer, and Back Contour device (See Table 2, page 10). Other than radiography, all screening techniques depend on surface topography (Bunnell, 2005).

Radiography

Using radiography to determine the Cobb angle measure of spinal curvature is the gold standard in the assessment of scoliosis (Raso, Lou, Hill, Mahood, Moreau, and Durdle, 1998). See Table 2, page 10. The Cobb angle is formed by the least number of vertebrae that produce the maximum degree of angulation or curvature of the spine. To determine the Cobb angle, perpendicular lines are drawn from horizontal lines defining the end plates of the highest vertebrae involved and the lowest vertebrae involved. The angle that is formed by the two perpendiculars is a measurement of the degree of angulation over the extent of that curve, called the Cobb angle. The intraobserver variability in measuring Cobb angles averages up to 5˚ with a single film, while there is as much as 7.2˚ interobserver error (Killian *et al.*, 1999)

Radiographs are required in order to diagnose spinal deformity, as well as to determine its etiology, severity (Bunnell, 2005), site, and the child's maturity (Lonstein, 1989). Radiographs can not be used for mass screening because they are not only costly (Karachalios, Sofianos, Roidis, Sapkas, Korres, and Nikolopoulos, 1999), but can be hazardous to young, developing children by exposing them to higher than normal amounts of radiation. For the initial evaluation, a standing posteroanterior view is necessary (Lonstein, 1989), taken on a 14x17-inch or 14x36-inch film (Lonstein, 1988), and if hyperkyphosis is present, a lateral view is taken as well (Lonstein, 1989). The single film should obtain the lower cervical spine, entire thoracic and lumbar spine, as well as the pelvis, and results in slight marrow radiation (Killian *et al.*, 1999).

Adam's Forward-Bending Test

The Adam's forward-bending test (FBT) is the most common tool used in school scoliosis screening. See Table 2, page 10. The FBT begins with a visual inspection while the child stands erect. It is preferred that the child have a bare back, allowing deformities to be seen more easily. The screener looks for shoulder height asymmetry, unilateral high hip, asymmetrical scapular prominence, unequal arm-to-thigh length, and noncentering of the head. Then the child bends 90˚ at the hips, knees locked, with their arms dangling and their palms together. The screener looks from both the side and back, checking for unequal floor-to-fingertip distance, unilateral rib hump deformity, asymmetry of scapular prominence, and gross lateral deviation of the spine (Gunnoe, 1990).

This FBT is relatively quick, inexpensive, and easy to perform, as well as safe (Karachalios *et al.*, 1999). According to a study done by Karachalios *et al.* (1999), the FBT has a sensitivity of 84% and specificity of 93%. However, it had more false-negative (misses scoliosis cases) findings than any of the other tools evaluated in the study, which were the scoliometer, humpometer, and Moire topography. On the other hand, it had the least false-positive findings of all the evaluated tools, meaning that it is referring fewer children who do not have scoliosis (Karachalios *et al.*, 1999). Wong *et al.* (2005) states that the FBT's rate of false-

positives varies between 25-82% and also that the false-positive rate remains at over 70% for boys of all ages, but decreases for girls as they get older.

Scoliometer

The scoliometer is a screening tool used in conjunction with the FBT. See Table 2. The scoliometer is commonly used because it is easy and convenient. Also, by providing guidelines for referral, it standardizes the means of scoliosis screening (Bunnell, 1984). The scoliometer is placed on the child's back (Gunnoe, 1990), similar to a carpenter's level (Rooney and Akbarnia, 2004), while the child is bent over and parallel to the floor (Gunnoe, 1990). An air bubble in a tube of liquid rises to a numbered mark on the instrument (Rooney and Akbarnia, 2004). This numbered mark tells the difference in angular degrees in height between each side of the thorax, due to apical trunk rotation (Gunnoe, 1990). The resulting number is called the angle of trunk rotation, or ATR (Karachalios *et al.,* 1999), which can serve to document curve progression (Bunnell, 1984). Amendt, Ause-Ellias, Eybers, Tadsworth, Nielsen, and Weinstein (1990) found a weak, but significant correlation between the Cobb angle and the ATR. *For more information and photographs of the scoliometer in conjunction with the FBT, see the 2003 Scoliosis Screening Manual, pages 14 through 18.*

The scoliometer is very sensitive to false negative results (Pearsall *et al.,* 1992). In Bunnell's study (1984), over half the patients with minor scoliosis (Cobb angle less than 20˚) had been determined as positive by the scoliometer method, and thus were false-positives. The study by Karachalios *et al.* (1999) found it resulted in 27 false-negatives out of 2,700 students screened (1%), and 419 false-positives (15.5%). They calculated the scoliometer's sensitivity to be 90.62% and specificity of 79.76%.

The study by Goldberg *et al.* (1995) in Dublin identified a false-positive rate of 92%, where 61 children were referred and only five had scoliosis. They calculated a sensitivity of 83% and specificity of 99%. The false-positive rate decreases with increasing age, as seen by Wong *et al.* (2005), with boys decreasing from 82% in ages 6-7 and 9-10 down to 71% in ages 11-12 and 13-14, similarly for girls decreasing from 75% to 50%. Amendt *et al.* (1990) points out that the sensitivity and specificity depend on what ATR angle criterion is being used to determine what a positive test is.

Moire topography

Moire topography is a noninvasive photo-stereo-metric method that measures asymmetry of the body surface resulting mainly from rib and muscle deformities (Karachalios *et al.,* 1999). A three-dimensional photograph is produced with topographic contour lines of the subject's back (Gunnoe, 1990). Some researchers find a correlation between this method and an internal spinal curvature, while others do not (Pearsall *et al.,* 1992). The study by Karachalios *et al.* (1999) found that using this method resulted in just one false-negative out of 2,700 students screened. But the method also resulted in 269 false-positives, for a sensitivity of 100% and a specificity of 85.38%. Moire topography is expensive and time-consuming (Bunnell, 2005), in part because the method is a complex procedure that requires great expertise (Pearsall *et al.,* 1992), making use impractical for mass screening (Bunnell, 2005).

Other tools (Humpometer and Back Contour)

There are several other tools available for studying back shape abnormalities that are not commonly used, including raster stereography, the humpometer, ultrasound real-time linear array

scanner, optoelectronic circumferential scanning, and digitization of the spinous processes. Integrated shape-imaging system is also an uncommon tool (Karachalios *et al.,* 1999), which Bunnell (2005) points out is too time-consuming and expensive to be used for mass screening.

The back contour device is another tool developed for scoliosis screening, which consists of a level from which a series of movable rods pass through. The rods can be locked into position to record the contour of the patient's back surface, while in the forward-bending position. Some studies find a correlation between these measurements and lateral curvature, while others do not (Pearsall *et al.,* 1992).

Table 2: Summary of Scoliosis Screening Tools

	Sensitivity	Specificity	Inter-rater Agreement	False-Positives (S	Time spent/ child	Cost
Radiography	**Gold Standard[1]**	**Gold Standard[1]**	**92.8%[6]**	**Gold Standard[1]**	**Not cited**	**Expensive[2]**
Adam's Forward Bend Test (FBT)	84%[2]	93%[2]	88%[2]	25-82%; (>70% for boys of all ages & decreases for girls as they get older[3])	30 seconds[2]	Inexpensive[2]
Scoliometer	90.62%[2], 83%[4]	79.76%[2], 99%[4]	80%[2]	15.5%[2], (71-82% in boys, 50-75% in girls[4)]	20 seconds[2]	FBT + cost of a scoliometer[4]
Moire Topography	100%[2]	85.38%[2]	85%[2]	9.96%[2]	40 seconds[2]	Expensive[5]
Humpometer A	93.75%[2]	78.11%[2]	88%[2]	17.15%[2]	1 minute, 10 seconds[2]	Not cited
Humpometer B	87.5%[2]	62.1%[2]	88%[2]	32.96%[2]	See above	Not cited

[1]Raso *et al.,* 1998 [3]Wong *et al.,* 2005 [5]Bunnell, 2005
[2]Karachalios *et al.,* 1999 [4]Goldberg *et al.,* 1995 [6]Killian *et al.,* 1999

Referrals and Follow-Up

Screening is a sorting process, not diagnostic, that aims to select those who may have the disease. Some children will be selected for diagnostic evaluation who are found to be normal (a false positive), and some will be considered normal who actually do have the disease (a false

negative). "The later situation is felt to be the worst, and thus, most screening programs have more false positives than false negatives." (Morrissy, 1999). A balance favoring false positives "leads to one of the largest dilemmas in screening: are the anxiety, cost, and morbidity of the false positives worth the earlier detection of the true positives?" (Morrissy, 1999). According to Velezis, Sturm, and Cobey (2002), only 1% of subjects screened and 10% of those with positive findings referred on will actually need treatment. Rooney and Akbarnia (2004) state that because the prevalence of adolescent idiopathic scoliosis is so low, six children without scoliosis are referred for every one child who has scoliosis.

Many studies have been done to look at the referral rates for scoliosis and the number of false positive results. For example, Huang (1997) did a study in Taiwan in 1994. The referral rates are as follows: 5.2% for 5˚ or more; 2.4% for 6˚ or more; 1.4% for 7˚ or more; 0.7% for 8˚ or more; 0.5% for 9˚ or more; 0.3% for 10˚ or more. A study from Washington, D.C. over a 7-year period (from 1989 to 1990 school year through 1995 to 1996 school year) showed a 2% referral rate. But of those referred, only 47% reported for care, the conclusion being that those being referred are not all following up (Velezis *et al.*, 2002). A study in Canada (Beausejour, Roy-Beaudry, Goulet, and Labelle, 2007) looked at patients' initial visits after referral from May 1st, 2003 to April 30th, 2004. Of 489 patients, 206 (42%) were deemed "inappropriate referrals" due to their spinal Cobb angle being less than 10˚. Yet 91 (19%) were considered late referrals because their curves were already severe enough to require immediate treatment.

Cost-Effectiveness

The cost-effectiveness of school screening programs has been a matter of great debate. There has been a lot of research and the conclusions vary widely. Some authors suggest that there are a large number of false-positive results in most reported mass school screening programs, resulting in many children being referred for x-rays and ultimately found to be normal or have inconsequential spinal curves (Karachalios *et al.,* 1999).

Reports of the cost per screening vary widely and include $0.066 (Lonstein *et al.,* 1982), $0.30 to $6.60 (Rooney and Akbarnia, 2004) and $34.40 (Yawn and Yawn, 2000). The factors each study considered in their estimates may account for much of the differences. The small cost estimates consider the salary of the state-wide coordinator and the workshop manuals, brochures, and mailings (Lonstein *et al.,* 1982). The estimate by Yawn and Yawn (2000) includes the aforementioned cost factors along with costs of all necessary and unnecessary medically induced care.

Some researchers calculate the cost-effectiveness of the school screening program per case found, instead of per child screened. These data depend upon the criteria used to define scoliosis. Yawn and Yawn (2000) state that identifying children with curves of 11-19˚ Cobb angles by age 19 may be of limited use, because these children are unlikely to need treatment. They found that it cost $4,198.67 to find one child with a curve greater than or equal to 20˚. The cost per case treated was $15,115.20. Also, the cost of finding a child with a curve of more than 20˚ by age 19 is higher than the cost of finding hepatitis C by screening, at $1,246 per case.

Morais, Bernier, and Turcotte (1985) found that the screening process costs $194.27 per confirmed case of scoliosis. The cost per case of scoliosis that was brought to immediate treatment was $3,505.49. This raises the question as to whether the total cost of screening programs is equal to or greater than the cost of not screening. The problem of over-referral

dramatically escalates the total cost of screening (Bunnell, 2005), so finding a way to decrease false-positive results is important.

IV. History and Current Practice of School Scoliosis Screening in Minnesota

The first training session for scoliosis screening in Minnesota was held in Duluth in 1973 (S. Stubblebine, MDH Public Health Social Worker, personal communication, 10/12/07). Since 1973, MDH was the lead agency and organized the training and resource materials (see Appendices A, B, and C), and collected screening results from schools. A school scoliosis screening report (see Appendix D) was provided to schools, and these were submitted annually to MDH's Maternal and Child Health Section upon completion of the screening and follow-up. This information was used to estimate the incidence and prevalence of scoliosis in Minnesota. It also provided a measurement of the effectiveness of the school scoliosis screening program in maintaining early detection and preventing progressive spinal deformity (School Screening for Scoliosis, 1999).

The MDH Minnesota Children with Special Health Needs (MCSHN) program taught school nurses how to screen and actively assisted school nurses in doing secondary screening (J. Olstad, MDH Assistant Division Director, personal communication, 10/01/07). The program was started because the significant spinal curvatures were not being caught early enough, so there were a lot of children requiring braces or surgery (B. Goodman, Social Work Consultant to MDH, personal communication, 09/14/07).

MCSHN recommended screening both boys and girls, generally grades 5-9 (M. Wanninger, MDH Public Health Social Worker, personal communication, 09/26/07), sometimes with girls starting at younger ages and boys finishing at older ages. Screening used the Adam's forward bending test, without the scoliometer as it had not been invented (S. Stubblebine, Public Health Social Worker, personal communication, 10/12/07). Later the scoliometer was used, with a 5˚ ATR as the criterion for referral. Although school scoliosis screening was never mandated in Minnesota, it was strongly recommended and at its peak 94% of all state schools were participating (M. Wanninger, MDH Public Health Nursing Supervisor, personal communication, 09/26/07).

The surveillance practice was discontinued in 2000 when MDH began to no longer maintain a scoliosis database and reporting system, one reason due to the data being unrepresentative, which lowered the validity and reliability, thus making the data difficult to analyze. However, MDH did continue to encourage each school to maintain its own system for data collection for estimating incidence and prevalence of scoliosis in the school district/community by using an altered school screening report (see Appendix E). (School Screening for Scoliosis, 2000)

In 2003 MDH collaborated with Gillette Children's Specialty Healthcare and the Twin Cities Spine Center on School Screening for Scoliosis. In this collaboration, Gillette has taken the lead with training and training materials (see Appendices F and G). Currently the training workshops, now hosted by Gillette Children's Specialty Healthcare, teach using 7˚ ATR as the referral mark (School Scoliosis Screening, 2003).

Since the school scoliosis screening programs began in Minnesota, challenges have included compliance, education, staffing, physician referral, and reporting. With constraints in resources, less staff are available for screening, especially because the nurse's position is often the first to be cut (Lonstein, 1988).

V. Screening Recommendations

Recommendations of Professional Organizations

See Table 3, page 14, Current School Scoliosis Screening Recommendations by Organization.

In 2003, the Canadian Task Force on the Periodic Health Examination concluded there was insufficient evidence to recommend screening (Beausejour *et al.*, 2007). The United States Preventive Services Task Force (USPSTF) has revised its 1994 screening recommendations from neutral to recommending against scoliosis screening in 2005. Potential harms identified by the USPSTF include: unnecessary follow-up visits and evaluations due to false positive screening results; interventions not significantly improving back pain or quality of life of those diagnosed with idiopathic scoliosis; and, psychological adverse effects related to interventions, especially related to brace-wear. The USPSTF concluded that the harms of screening adolescents for idiopathic scoliosis exceed the potential benefits. While the USPSTF recommends against routine screening of asymptomatic adolescents for idiopathic scoliosis (USPSTF, 2005), they recommend that "clinicians should be prepared to evaluate routine screening of adolescents for idiopathic scoliosis when it is discovered incidentally or when the adolescent or parent expresses concern about scoliosis."

A 2007 Joint Statement by the American Academy of Orthopaedic Surgeons, the Scoliosis Research Society, the Pediatric Orthopaedic Society of North America, and the American Academy of Pediatrics states that they "do not support any recommendations against scoliosis screening" (Richard and Vitale, 2007). In the 2007 Joint Statement, the professional organizations expressed concern that the USPSTF's recommendation against screening was not supported by the literature or significant input from specialists in the field. All four organizations agree that "females should be tested twice, at ages 10 and 12 (grades 5 and 7), and boys once, at age 13 or 14 (grades 8 or 9)." The American Chiropractic Association (1991) also continues to support school scoliosis screening programs.

School screening is carried out routinely in Sweden, Denmark, Singapore, and Japan (Fazal and Edgar, 2006). In a 2000 national survey, when states were asked if they had a policy stating that districts or schools will screen students for scoliosis, 27 states replied "yes," that their state does mandate school scoliosis screening (National Center for Chronic Disease Prevention and Health Promotion, 2006). Later surveys indicated that two of those "yes" states were repealing their mandate (Song *et al.*, 2008). Minnesota has never mandated school scoliosis screening.

In 2007, MDH informally surveyed states on their scoliosis screening policies. However, only 11 states responded. Five of the 11 responding states currently have statutes requiring scoliosis screening to be done in schools (TX, CN, VA, KY, and PA). One state had the alternative option of sending home information about the need for scoliosis screening (VA). Of the remaining six states, three are in the process of or recently have repealed their mandatory screening laws (IN, MD, and FL). The other three (OR, OK, and OH) do not require school scoliosis screening, but some of their schools do continue to run screening programs.

Table 3: Current School Scoliosis Screening Recommendations By Organization:

Organization	Recommends school scoliosis screening	Does not recommend school scoliosis screening
American Academy of Orthopaedic Surgeons (2007) http://www.ejbjs.org/cgi/content/full/90/1/195#SEC2	X	
American Academy of Pediatrics (2007) http://www.ejbjs.org/cgi/content/full/90/1/195#SEC2	X	
American Chiropractic Association (1991) http://www.acatoday.com/level2_css.cfm?T1ID=10&T2ID=117#92	X	
American Nurses Association (2008)*[1]		
Canadian Task Force on the Periodic Health Examination (2003) http://www.ctfphc.org/		X
National Association of Pediatric Nurse Practitioners (2008)*[2]		
National Association of School Nurses (2008)*[3]		
Pediatric Orthopaedic Society of North America (2007) http://www.ejbjs.org/cgi/content/full/90/1/195#SEC2	X	
Scoliosis Research Society (2007) http://www.ejbjs.org/cgi/content/full/90/1/195#SEC2	X	
United States Preventive Services Task Force (2005) http://www.ahrq.gov/clinic/3rduspstf/scoliosis/scoliors.htm		X

*Does not currently have a position statement regarding school scoliosis screening
[1] *http://nursingworld.org/* [2] *http://www.napnap.org* [3] *http://www.nasn.org/*

Age and Gender-Based Screening Recommendations

It is important to look at the risk factors, such as age and gender that are most likely to be associated with spinal curvatures when running a screening program. Wong *et al.* (2005) found that girls ages 11-12 and 13-14 years old best fit the screening criteria in their study. In the younger age groups and in boys of all age groups, the screening program was not as efficient because the prevalence of scoliosis was low and the curve magnitudes were usually small. These latter groups also had much higher false-positive rates. Bunnell (2005) states that the risk of curve progression, as well as the risk of requiring spinal correction and fusion is nearly ten times greater in females than in males. Bunnell suggests screening only females to reduce the screening burden by 50%.

Referral Recommendations

Looking at the appropriate angle of trunk rotation (ATR) criteria for referral also has a large influence on the efficiency of the scoliosis screening programs. Samuelsson and Noren (1997) suggest that different ATRs can be used for referral depending on whether the curve is thoracic, lumbar, or thoracolumbar, but additional literature on this is limited. Huang (1997) concluded that an ATR of 5˚ supplies 100% sensitivity and 47% specificity, while the ATR of 7˚

has a sensitivity of 83% and a specificity of 86%, which minimized false-positive referrals without missing a large number of cases.

Bunnell (2005) suggests that a patient with an ATR of 5˚ or less should be dismissed without rescreening, because the mean Cobb angle in patients with at 5˚ ATR was only 11˚. Adolescents with an ATR between 5˚ and 10˚ should be rescreened every 6 months and females until a year after the occurrence of menarche. Emphasis is placed on the importance of documentation and follow-up by school health personnel. Lastly, individuals with an ATR of 10˚ or more should be immediately referred for medical evaluation and x-ray. This is a change from Bunnell's previous suggestion (1993) recommending referral for 7˚ or more ATR, considering a 30˚ Cobb angle as requiring treatment and would result in a referral rate of 3% and should detect 95% of all treatment eligible curves.

Current MDH referral recommendations can be found in the 2003 ***Scoliosis Screening/A Manual*** (pages 4-5). The MDH recommends making a referral to a primary care provider if students (1) exhibit a 7 degree or greater difference in lumbar or thoracic areas as measured by a scoliometer (2) exhibit lordosis (excessively inverted lower back) (3) exhibit kyphosis (excessively round back) or (4) exhibit other obvious abnormality. Also the MDH currently recommends making a "Watch" List of students with lumbar or thoracic discrepancies of 5 to 6 degrees or with other questionable findings. Students who meet criteria for monitoring should be rescreened within three months. Parents of students who meet the criteria for referral or monitoring should be notified. Discussion should include screening results and emphasize that results are not diagnostic. It should also be emphasized that further medical evaluation may be needed and that the child could require treatment.

VI. Conclusions

Several professional organizations recommend screening for scoliosis in schools with girls at ages 10 and 12 (grades 5 and 7) and boys at age 13 or 14 (grade 8 or 9). However, the USPSTF and the Canadian Task Force do not recommend screening for scoliosis in schools. The latter (USPSTF) reports that the harms of screening outweigh the benefits.

The Adam's forward-Bending Test (FBT) is the most common tool used in school scoliosis screening. The scoliometer is used in conjunction with the FBT because it is easy, convenient, and economical. The FBT has a sensitivity of 84% and specificity of 93% and in conjunction with the scoliometer, sensitivity is 83-91% and specificity is approximately 90-99%.

Referral criteria are based on the angle of trunk rotation (ATR), which is measured by the scoliometer. It is suggested that a adolescents with an ATR of 5°or less should be dismissed without further screening. Further, adolescent females with ATR between 5° and 10° should be rescreened every six months until a year after the occurrence of menarche. The MDH recommends that students are to refer to the primary care provider if they exhibit a 7° or greater ATR and to rescreen those with ATR of 5° to 6° within three months. Also school screening referrals to the primary care provider are recommended for suspected lordosis (excessively inverted lower back), kyphosis (excessively round back) and other obvious abnormality.

VII. Next Steps

The information in this review serves as a guide for the MDH Scoliosis School Screening Workgroup to make their recommendations to the MDH. We suggest the work group members focus their recommendations on the following key questions:

Question 1:

What could be the MDH's overall recommendation for school scoliosis screening?

Options include recommending the following: (See Review of the Literature, Table 1, p. 7)

A. Universal Screening - screen all children ages 10-15 yearly.
B. Targeted Screening - selectively screen based on research; females ages 10 and 12, males age 13 or 14.
C. No Screening – no screening of any children in schools
D. Neutral - do not make recommendation for or against scoliosis screening in schools.

Current Recommendation:
MDH encourages school districts – in collaboration with local primary-care providers – to selectively screen for scoliosis. (***Scoliosis Screening/A Manual***, p. 2)

Question 2:

What could the periodicity schedule be for school scoliosis screening – i.e. to screen at what age(s) for males and females?

Points to consider:
It is important to consider the risk factors that are most likely to be associated with spinal curvatures when running a screening program, including age and gender. It is well-documented that females have a much higher prevalence of scoliosis than males, and that the majority of these cases occur before puberty. (See Review of the Literature, pp. 13-15)

Current Recommendations:
MDH recommends screening girls/females in fifth grade (11 years) and again in eighth grade (14 years). Boys/males should be screened in eighth grade (14 years) or ninth grade (15 years). (***Scoliosis Screening/A Manual***, p. 2)

Question 3:

What screening methods could be used?

Options include recommending methods performed by trained screeners:

A. Visual Examination
B. Adam's forward-bending test (FBT)
C. Adam's forward-bending test (FBT) with the scoliometer
D. Other

Points to consider:
There are many screening instruments available, offering more accurate findings than visual examination alone. Using the common combination of the scoliometer with the Adam's forward bending test (FBT) is a simple and affordable method. (See Review of the Literature, pp. 8-10)

Current Recommendation:
The MDH recommends using the Adam's forward-bending test (FBT) with the scoliometer. (Scoliosis Screening/A Manual, pp. 4 and 15-18). In the ***Scoliosis Screening/A Manual*** (p. 3), it is recommended that "All screeners, including school nurses, physical-education and other teachers, volunteers, doctors, nurse practitioners and anyone else involved in the screening program – should attend the Scoliosis Screening Seminar" which is held annually in the Twin Cities.

Question 4:

What constitutes referral criteria for school scoliosis screening? To whom could a child be referred? What criteria could be used to rescreen a child in a school and how often could rescreening occur?

Points to Consider:
Referral criteria are based on the angle of trunk rotation (ATR), which is measured by the scoliometer. It is suggested that a adolescents with an ATR of 5°or less should be dismissed without further screening. Adolescent females with ATR between 5° and 10° should be rescreened every six months until a year after the occurrence of menarche.
See Review of the Literature, pp. 8-12

Current Recommendations:
The MDH recommends that students are to refer to the primary care provider if they exhibit a 7° or greater ATR and to rescreen those with ATR of 5° to 6° within three months. Also school screening referrals to the primary care provider are recommended for suspected lordosis (excessively inverted lower back), kyphosis (excessively round back) and other obvious abnormality. See ***Scoliosis Screening/A Manual***, pp. 4-5 "Step 3: Referrals and Monitoring.

Question 5:

What could the role of MDH be in scoliosis screening in schools?

(See Review of the Literature pages 12-13)

Current role:

MDH currently supports activities of Gillette Children's Specialty Healthcare and Shriners Hospitals for Children including the ***Scoliosis Screening/A Manual*** publication.
Data Surveillance - As of 2000, the MDH no longer maintains a scoliosis database. Schools are encouraged, however, to collect data about the prevalence of scoliosis in their communities. (***Scoliosis Screening/A Manual***, p. 5)

MDH does not provide recommendations or information on scoliosis on its website nor do we provide written or audio-visual materials for students, parents, professionals, etc. MDH school and child health consultants do provide limited technical assistance and consultation, primarily referring persons to Gillette or Shriners.

Appendix A
Letter to parents regarding screening
(School Scoliosis Screening, 1999)

Appendix B
Referral letter
(School Scoliosis Screening, 1999)

Appendix C
Scoliosis update form
(School Scoliosis Screening, 1999)

Appendix D
School scoliosis screening report
(School Scoliosis Screening, 1999)

Appendix E
School scoliosis screening report
(School Scoliosis Screening, 2003)

Appendix F
Letter to parents regarding screening
(School Scoliosis Screening, 2003)

Appendix G
Referral letter
(School Scoliosis Screening, 2003)

Appendix A
Letter to parents regarding screening
(School Scoliosis Screening, 1999)

Dear Parents:

In the next few weeks, we will be conducting a screening program to find children with suspected curvature of the spine (Scoliosis). According to available information, two to five children in every 100 may develop scoliosis. Some will require treatment. If this condition is detected early and appropriately treated, progressive spine deformity can be prevented.

The procedure for screening is simple and consists of a 30 second test in which the screener (usually a school nurse or physical education teacher) looks at the child's bare back in a standing position and in a forward bending position.

If your child has a suspected curvature, you will be notified and asked to take the child to your primary health care provider for further evaluation.

If you do not wish your child to participate in this screening program, please submit a note indicating this to the school.

Sincerely yours,

_____
School Nurse

Appendix B
Referral letter
(School Scoliosis Screening, 1999)

Your child, _____, recently participated in our school scoliosis screening program.

This screening program is not a diagnostic service. However, the results have indicated that your child needs further evaluation to determine whether or not he or she has a spinal deformity and, if so, what treatment may be necessary. It is urged that you take your child to your primary health care provider for further evaluation.

The cause of the type of scoliosis commonly occurring in adolescents (side-to-side curvature of the spine) is unknown. It becomes more apparent during adolescence because of the growth spurt. This condition can more often be corrected if found at an early stage.

Please request that the examining physician complete this form when your child's evaluation has been completed and return it to the school health office (after the parent signature line has been signed*).

Please feel free to call me if you have any questions.

_____ _____
School Nurse Telephone Number

Doctor's Findings and Recommendation

I have examined _____ on _____

☐ Standing (Posterior-Anterior x-ray) shows _____

☐ No significant findings at this time _____

☐ Need for further evaluation _____

☐ Re-examination or treatment recommended (If so, date) _____

Additional comments:

Signed _____

Address _____

Telephone _____ _____
* Parent's Signature Line

Appendix C
Scoliosis update form
(School Scoliosis Screening, 1999)

Dear Parent or Guardian of _____

According to school health records, your child is being seen by a health care provider for curvature of the spine (scoliosis). In order to keep school records current, please ask your doctor to complete this form at your child's next appointment and return it to the school health office (after the parent's signature line has been signed*).

Thank You,

_____
School Nurse

To the Examiner:

In order to keep school records current and evaluate our screening program, please complete the following:

Doctor's Findings and Recommendation

I have examined _____ on _____

☐ Standing (Posterior-Anterior x-ray) shows: _____

☐ No significant findings at this time _____

☐ Need for further evaluation _____

☐ Re-examination or treatment recommended (If so, date) _____

Additional comments:

Signed _____

Address _____

Telephone _____ _____
* Parent's Signature Line

Appendix D
School scoliosis screening report
(School Scoliosis Screening, 1999)

MDH Minnesota Department of Health — Maternal Child Health

SCHOOL SCOLIOSIS SCREENING REPORT

School Name	
School District Name	District Number
County	City

SEE DIRECTIONS ON REVERSE SIDE FOR COMPLETING REPORT.

A. SCREENING RESULTS THIS SCREENING				B. REFERRAL RESULTS FOR THIS SCREENING									
1	2	3		4	5	6	7	8	9	10	11		
Grade M=Male F=Female	Total Number Screened	Number of Questionable Findings Not Referred	Number of Positive Findings Referred	Results of Referral for Professional Examination									
				Diagnosis				Recommended Scoliosis Treatment					
				Scoliosis	Normal	Other	Follow-up Incomplete	Observation	Bracing/ other	Surgery	None/ Unknown		
5F													
6F													
7F													
8M													
9M													
10M													
TOTAL													

Name of Person Completing this Report	School Year of this Report
Title of Person Completing this Report	
Telephone Number (include area code)	

Appendix E
School scoliosis screening report
(School Scoliosis Screening, 2003)

FOR INTERNAL USE ONLY
DO NOT SUBMIT TO MDH

SCHOOL SCOLIOSIS SCREENING REPORT

School Name	
School District Name	District Number
County	City

A. SCREENING RESULTS THIS SCREENING						B. REFERRAL RESULTS THIS SCREENING											
	1	2	3	4	5	6	7	8	9	10	11	12					
Grade M=Male F=Female	Total No. Enrolled	Screened	Findings Not Referred	Findings Referred	Results of Referrals for Professional Examination												
					Diagnosis				Recommended Scoliosis Treatment								
					Scoliosis	Normal	Other	Follow-up Incomplete	Observation	Bracing/ Other	Surgery	None/ Unknown					
5F																	
6F																	
7F																	
8M																	
9M																	
10M																	
TOTAL	Total No.	No. of Questionable	No. of Parents														

Name of Person Completing This Report
Title of Person Completing This Report
School Year of This Report

Appendix F
Letter to parents regarding screening
(School Scoliosis Screening, 2003)

Dear Parents:

In the next few weeks, we'll conduct a screening program to identify children who may have an abnormal curve of the spine (scoliosis). Studies estimate that two to five of every 100 children develop scoliosis, and some require treatment. Early detection and treatment help prevent or minimize the development of severe spinal deformities.

The screening procedure is simple. It consists of a 30-second test in which the screener — usually a school nurse or physical-education teacher — looks at a child's bare back while the child is standing and bending forward. We'll make every effort to ensure your child's privacy. Girls can wear a swimsuit and boys can wear swim trunks during the screening.

If your child appears to have a spinal curve, we'll notify you. Then we'll ask you to make an appointment with your primary health-care provider for further evaluation of your child's condition.

Please complete the form below, noting whether or not you'd like your child to participate in the screening program. Detach the form and return it to the school.

Sincerely,

______________________________ School Nurse

______________________________ Phone Number

- -

Detach here and return this form to your child's school.

☐ I do not wish to have my child, ______________________ (Name), screened for scoliosis.

______________________________ Parent Signature

Appendix G
Referral letter
(School Scoliosis Screening, 2003)

Dear Parents:

Your child, _____, recently participated in our school scoliosis screening program.

Although this screening program is not a diagnostic service, screening results indicate that your child needs further evaluation to determine whether he or she has a spinal deformity and, if so, what treatment may be necessary. We strongly recommend that you take your child to your primary health-care provider for further evaluation.

Scoliosis is a side-to-side curvature of the spine that can cause complications if left untreated. Although the cause is unknown, the condition becomes more apparent during the adolescent growth spurt. If detected early, scoliosis can be treated.

Please ask your child's physician to complete this form after your child's evaluation. Sign the form and return it to the school health office.

If you have additional questions, please don't hesitate to call me.

Sincerely,

_____ _____

School Nurse Phone Number

Physician's Findings and Recommendations

I have examined _____ on _____

Child's Name Date

Standing (posterior-anterior) X-ray shows:

- ☐ No significant findings at this time
- ☐ Needs further evaluation
- ☐ Re-examination recommended in _____ months
- ☐ Treatment recommended

Additional comments: _____

_____

_____

Physician Name (print) _____

Physician Signature _____

Clinic Name _____ Phone Number _____

Parent Signature _____

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Recommendation of the AAFP

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New training video:

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Video contains no mention or demonstration of scoliometer.