Age- and Sex-specific Prevalence of Scoliosis and the Value of School Screening Programs

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Abstract: A prevalence study of idiopathic scoliosis was conducted among 29,195 children of a community health district in the province of Quebec. The study was designed to determine whether a permanent screening program for idiopathic scoliosis was justified. The prevalence of the condition among school children aged 8 to 15 years was 42.0 per 1,000 in the screened population, 51.9 per 1,000 among girls, and 32.0 per 1,000 among boys. The positive predictive value of the bending test is estimated as 42.8 per cent for scolioses of 5° or more; it is only 6.4 per cent when curves of 15° or more are considered. The average cost of finding one child with a scoliosis of 5° or more is $194. Mass screening for idiopathic scoliosis does not seem to be justified in the present state of knowledge of the disease. (*Am J Public Health* 1985; 75:1377–1380.)

Introduction

After reviewing cases of adolescent idiopathic scoliosis identified through experimental or regular programs,[1–3] many researchers advocate screening school populations in certain age groups or grades. The major objection against screening is that it brings to periodic radiography a large number of children who do not and never will need treatment.[4,5] The present study was designed to answer some of the questions which must be considered before screening for idiopathic scoliosis may be implemented. What is the prevalence of the condition among school children aged 8 to 15 years in the target area? Given that a child shows a positive bending test, what is the probability that she or he has a curved spine? How much does it cost to identify one case of idiopathic scoliosis requiring medical attention? In the present state of knowledge of the disease, does idiopathic scoliosis meet the criteria of the World Health Organization for implementation of a screening program?[6]

Methods

During the 1977–78 academic year, 29,195 children aged 8 to 15 years (14,689 girls and 14,506 boys), were screened for idiopathic scoliosis. They made up 87.4 per cent of children registered in grades 3 to 10 of the public and private schools of a community health district of the Quebec City area (population 212,000) which includes both urban and rural communities. Children under 8 or over 15 years of age who attended the grades selected for the study were also screened but they are excluded from this report, because their numbers are insufficient to provide adequate prevalence estimates for their age group and they are not representative of their peers.

Clinical inspection of the symmetry of the back on bending forward is the most commonly used screening test for scoliosis. Efforts have been made to develop mechanical screening methods that do not rely on subjective appraisal. Moiré topography, the most recent one, is a photogrammetric technique which involves the recording of body contours that can be analyzed for unusual curvatures. There is no agreement between researchers about the reliability and accuracy of this method as compared to the bending test.[7,8] The forward bending test was thus used to ensure comparability of our results with those from other prevalence studies and to assess the validity of the test.[9]

Unequal rib prominence or unilateral lumbar protrusion on bending forward was defined as the positive sign of scoliosis. A screening record was completed for each child with a positive test. These children were given a letter addressed to their parents advising them to consult one of 14 participating orthopedic surgeons. Screening was performed in the schools, each child being examined by two specially trained nurses.

Each referred child was first to undergo clinical examination by an orthopedic surgeon, followed by an x-ray of the spine when deemed necessary. It was agreed that any curve of 5° or more, as measured by the Cobb method,[10] should be reported as a case of scoliosis. For each child, the orthopedic surgeon completed a form reporting presence or absence of idiopathic scoliosis, describing its type (simple or double), location (thoracic, thoracolumbar, or lumbar), and severity (in degrees). Reassessment and treatment recommendations were also recorded. A briefing session was held for participating orthopedic surgeons to ensure uniformity of the confirmation protocol. Screening test results and clinical reports were subsequently linked for each child. Up to two follow-up phone calls were required before a child failing to comply was considered lost for the purpose of this study.

We estimated the positive predictive value of the test, the probability that a child has a scoliosis given that his bending test was positive. The effect of varying the specificity of the test on its estimated predictive value was assessed, using the equation:

$$V = \frac{SP}{SP + (1-s)(1-P)}$$

where V is the positive predictive value of the test, S, its sensitivity, s, its specificity and P, the prevalence of the disease.[11]

Prevalence rates were analyzed through the logistic linear model[12] with age and sex as explanatory variables; age was considered to be quantitative. The age-prevalence relationship was not the same for boys and girls. Separate models were thus adjusted for each sex. The association between age, sex, and severity of the condition of scoliotic children was investigated by means of a log-linear model.[13]

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TABLE 1—Screening and Clinical Evaluation for Idiopathic Scoliosis

	Number	Per thousand	%
Children screened	29,195	1000	
Children with rib or lumbar humps	3,336	114	
Children submitted to orthopedic evaluation	2,868		100.0
Children with:			
scoliosis of ≥5°	1,227		42.8
other abnormalities	581		20.2
no abnormality	1,060		37.0

TABLE 2—Distribution of Idiopathic Scoliosis According to Severity of Spinal Curve by Sex

Curve (°)	Girls		Boys		Total	
	n	%	n	%	n	%
5–9	415	54.4	299	64.4	714	58.2
10–14	202	26.5	127	27.4	329	26.8
15–19	58	7.6	26	5.6	84	6.8
20–24	42	5.5	6	1.3	48	3.9
25–29	22	2.9	2	0.4	24	2.0
30–34	11	1.4	1	0.2	12	1.0
35+	13	1.7	3	0.6	16	1.3
TOTAL	763	100.0	464	100.0	1,227	100.0

Results

Prevalence

The screening test was positive for 3,336 children (114 per 1,000). Among them, 322 (9.7 per cent) refused any further examination or were lost to follow-up, 93 (7.8 per cent) went to their family physician, 53 (1.6 per cent) consulted a chiropractor, and 2,868 (86 per cent) were examined by an orthopedic surgeon. Results were available only for this last group. Idiopathic scoliosis was confirmed in 1,227 (42.8 per cent) of these 2,868 children. Other abnormalities including congenital scoliosis and unequal length of inferior limbs were found in 581 children (20.2 per cent). The remaining 1,060 (37.0 per cent) were dismissed as normal (Table 1).

The distribution of children according to severity of spinal curves by sex is described in Table 2. It shows that 80.9 per cent of girls' curves and 91.8 per cent of boys' measure less than 15°. Thirty-one per cent of the curves are thoracic, 37.3 per cent thoracolumbar, 22.2 per cent lumbar, and 9.5 per cent double major.

The prevalence of scoliosis among school children aged 8 to 15 years is 42.0 per 1,000. It is higher among girls (51.9/1,000) than among boys (32.0/1,000) (Table 3). The prevalence rate increases with age between 8 and 15, more markedly so for girls than for boys (Figure 1). Analysis of the data for each sex suggests an association between age of girls and severity of the condition. The proportion of older girls among those who have more severe curves is greater than that among girls with small curves. This is not so for boys. Sex-specific prevalence rates were calculated for five different definitions of the condition (Table 4). Prevalence of both small and large curves is higher in girls especially as degree of curves increases. The prevalence of cases needing treatment is very low in both sexes.

Among the 1,227 children with scoliosis, 487 (39.7 per cent) were given a follow-up appointment, physical exercise was recommended to 634 (51.7 per cent), while 38 (3.1 per cent) received no further advice. Immediate treatment was recommended to 68 children: intermittent traction for 36, braces for 25, and surgery for seven. Children brought to immediate treatment thus represent 5.5 per cent of all cases identified through screening and a rate of 2.3 per 1,000 children screened.

Validity and Direct Costs of the Screening Test

The estimated positive predictive values of the test are 42.8 per cent, 17.9 per cent, and 6.4 per cent, depending upon whether scoliosis is defined as a curve of at least 5°, 10° or 15°, respectively (Table 5).

Screening costs include the diagnostic costs and cover salaries, transportation, communications, and filing costs but exclude research costs. Professional fees and radiological services make up clinical confirmation costs. Unless otherwise stated, costs are expressed in 1979 Canadian dollars. Screening 29,195 children cost $67,440, an average of $2.31 per child. Clinical evaluation of 2,868 positive screenees cost $170,933 or $59.60 per referred child including the cost of x-rays. From total costs of $238,373, the cost per case of confirmed scoliosis is estimated at $194.27, and the cost per case of scoliosis brought to immediate treatment is $3,505.49 (Table 6).

Discussion

Since the surveyed population comprised both urban and rural areas and its other sociodemographic characteristics were similar to those of the province of Quebec, the prevalence of idiopathic scoliosis as estimated in this study is probably a good indicator of its prevalence throughout the province, in the 8 to 15 years age group. Rogala, *et al*,[3] conducted a similar study in the Montreal area and obtained a prevalence estimate of 45 per 1,000. Other estimates obtained in a population of Caucasian children range from 12 to 153 per 1,000.[14] Only two out of the 11 estimates exceed 75 per 1,000. The highest one was obtained in a pilot study in which less than 1,000 children were screened. Brooks, *et al*,[1] report a prevalence of 136 per 1,000, but their population and screening procedure differ from ours. In the present study, it is likely that 42.0 per 1,000 slightly underestimates the true prevalence of the disease in the screened population not only because a number of small curves went undetected but also because children who failed to seek the advice of an orthopedic surgeon are included in the denominator of this estimate while cases of scoliosis among these children could not be counted in the numerator. If the proportion of children with scoliosis among those who did not consult an orthopedic surgeon were the same as among those who did, the estimated prevalence rate would rise to 54.0 per 1,000, a value still close to that of Rogala, *et al*.[3]

The distribution of curve location along the spine among Quebec City children differs significantly ($p < 0.0001$) from that reported by Rogala, *et al*,[3] mainly because of a higher rate of lumbar curves and lower rate of double major curves in our study.

From the equation linking the positive predictive value of a screening test to the prevalence of the disease, it may be shown that even a highly specific test will perform poorly when the prevalence of the disease is low. Even if the prevalence of scoliosis were higher in the screened population, it would not significantly improve the positive predictive value of the test. Some programs restrict screening to girls aged 10 to 14 years who are more likely to have severe curves.[15] But minor scoliosis is also more frequent among 11

TABLE 3—Age and Sex Specific Prevalence of Scoliosis (per thousand) According to Severity of Spinal Curve

	Age (years)								
Curve (°)	8	9	10	11	12	13	14	15	8–15
Girls									
5–14	25.2	27.9	36.0	43.7	35.4	51.8	53.6	48.7	42.0
15–24	1.7	2.4	1.7	3.9	6.8	7.1	11.9	13.6	6.8
25–34	1.7	0.6	0.0	1.1	4.2	1.8	3.5	3.9	2.2
35+	0.9	0.0	0.5	0.0	2.1	0.4	0.9	1.9	0.9
5+	29.6	31.0	38.4	48.8	48.6	61.2	70.0	68.2	51.9
Boys									
5–14	24.1	29.2	25.2	28.7	26.5	31.0	25.5	41.0	29.4
15–24	0.8	0.6	1.9	1.1	1.1	3.1	3.6	3.8	2.2
25–34	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.9	0.2
35+	0.0	0.0	0.0	0.0	0.0	0.4	0.5	0.5	0.2
5+	24.9	29.9	27.1	28.8	27.6	35.1	29.6	46.3	32.0

TABLE 4—Sex Specific Prevalence of Idiopathic Scoliosis According to Five Definitions of the Disease (per thousand)

Definition of Scoliosis	Girls	Boys	Total
≥ 5°	51.9	32.0	42.0
≥10°	23.7	11.4	17.6
≥15°	9.9	2.6	6.3
≥20°	6.0	0.8	3.4
≥25°	3.1	0.4	1.8

TABLE 5—Estimated Positive Predictive Value of the Forward Bending Test for Five Definitions of Scoliosis

Definition of Scoliosis	Number of Children with Confirmed Scoliosis	Positive Predictive Value (%)
≥ 5°	1227	42.8
≥10°	513	17.9
≥15°	184	6.4
≥20°	100	3.5
≥25°	52	1.8

to 14 year old girls than among the 8 to 10 year-olds. Indeed, if screening had been restricted to girls aged 11 to 14 in our study, the estimated predictive value of the bending test would not be much higher: 58.4/1,000 for curves of 5° or more, 27.4/1,000 for curves of 10° or more, and 22.3/1,000 for curves of 15° or more. Burwell, *et al*,[9] found that a rib hump may be a normal finding in school children and concluded that the forward bending test is inadequate. There is no general agreement as to the nature of the link between a hump and the vertebral rotation which results in a measurable curve. It is emphasized[9] that a positive bending test does not justify radiography of the spine. A rib hump is at best a warning sign calling for clinical evaluation. Yet, 13 of the 14 collaborating orthopedic surgeons in this study required a radiological examination before reaching diagnosis. In planning this study, it was assumed that about 20 per cent of referred children would need a radiography. The orthopedic surgeons decided that this was necessary in 89 per cent of cases. Leaver, *et al*,[14] also conclude that screening for scoliosis is not justified because the value of the most commonly used screening test is either unknown or known to be poor. The present results support their conclusion.

Not only does the bending test produce large numbers of false positives, it also identifies a fair number of true positives who may never need treatment. Given the large proportion of positive screenees with minor scoliosis to whom periodical reassessment was recommended, it appears that these children will repeatedly and unnecessarily be exposed to x-rays. Some of them may even be submitted to the trauma of treatments such as a brace or traction. The variation of the prevalence of small curves with age (Table 3) suggests that a large proportion of minor scolioses are not progressive.

The main goal of screening programs is the early detection of asymptomatic health problems, in order to provide affected individuals with an effective treatment that will favorably alter the course of the disease.[16] This goal cannot be attained by the screening methods now available. Minor cases which are likely to progress need to be identified, but they are undistinguishable from small curves which never become health problems. More research is needed to develop a screening test which will permit identification of progressive cases while being ethically acceptable.

It has been argued that screening for scoliosis is quite inexpensive and should therefore be implemented.[2,17] This argument is based on estimates of average cost per screenee rather than estimates of average cost per case of scoliosis in need of medical attention. This practice is not in agreement with cost-benefit analysis principles because it distorts considerably the size and shape of aggregate health resources

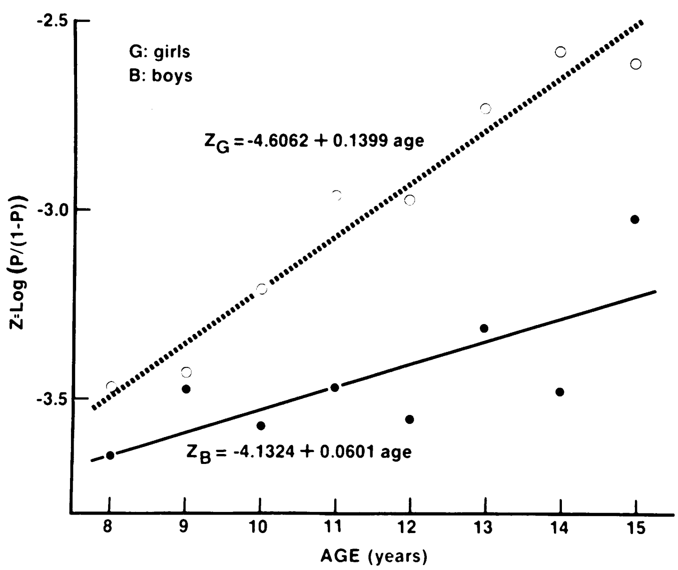

FIGURE 1—Logit Transform of the Proportion P of Scolioses with Respect to Age and Sex (≥ 5°)

TABLE 6—Estimated Cost of Finding One Case of Idiopathic Scoliosis

Quebec 1979	Total (Canadian $)*	Cost per Child (Canadian $)
Screening (29,195 children)	67,440	2.31
Diagnostic evaluation (2,868 children)	170,933	59.60
Case finding costs	238,373	
Case finding cost per		
1. case of confirmed scoliosis (N = 1,227)		194.27
2. scoliosis brought to treatment (N = 68)		3,505.49
Minnesota 1979–80[2]	(US $)	(US $)
Screening (255,707 children)	106,507	0.42
Diagnostic evaluation (9,205 children)	303,765	33.00
Case finding costs	410,272	
Case finding cost per		
1. case of confirmed scoliosis (N = 3,069)		133.68
2. scoliosis brought to treatment (N = 106)		3,870.49

*In 1979, 1 US $ = 1.17 Canadian $.

spent on screening for a given disease.[18] Data from this study may be compared with those obtained from Lonstein, *et al*, in Minnesota,[2] (Table 6). Although the cost per screenee is five times greater in this study than it was in Minnesota, the case finding costs are of the same order of magnitude. Both sets of data show that the average cost per case in need of medical attention may be many times larger than average cost per screenee. Cases in need of medical surveillance have been defined conservatively in this study. Indeed, there is no consensus with regard to the clinical significance of idiopathic scoliosis measuring less than 20°. Had the smaller curves been ignored, the contrast between estimates of cost per case and cost per screenee would have been even more striking.

The issue of the effectiveness of such programs, however, remains unresolved. In a subgroup of the population screened by Rogala, *et al*,[3] in Montreal, the natural evolution of even the more severe curves six years after screening showed no apparent relation to compliance with treatment.[19] Thus, it may be rather difficult to define, let alone value, the benefits of screening for scoliosis.

Although clinical examination of children's back on bending forward should remain part of the family doctor's routine examination procedure, we believe, in light of the present results and foregoing discussion, that school screening for idiopathic scoliosis is not justified. Where such programs exist, they should be rigorously evaluated.

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ERRATUM

In: Garfield RM, Taboada E: Health services reforms in revolutionary Nicaragua. (commentary) Am J Public Health 1984; 74:1138–1144. In Figure 3, p 1142, two of the explanatory captions within the Figure are mislabeled: both "Primary Health Units" and "Beds" should read "per 1000 persons," not per 100 persons.