

The Prevalence of Idiopathic Scoliosis in Eleven Year-Old Korean Adolescents: A 3 Year Epidemiological Study

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Purpose: School screening allows for early detection and early treatment of scoliosis, with the purpose of reducing the number of patients requiring surgical treatment. Children between 10 and 14 years old are considered as good candidates for school screening tests of scoliosis. The purpose of the present study was to assess the epidemiological findings of idiopathic scoliosis in 11-year-old Korean adolescents. **Materials and Methods:** A total of 37856 11-year-old adolescents were screened for scoliosis. There were 17110 girls and 20746 boys. Adolescents who were abnormal by Moiré topography were subsequently assessed by standardized clinical and radiological examinations. A scoliotic curve was defined as 10° or more. **Results:** The prevalence of scoliosis was 0.19% and most of the curves were small (10° to 19°). The ratio of boys to girls was 1:5.5 overall. Sixty adolescents (84.5%) exhibited single curvature. Thoracolumbar curves were the most common type of curve identified, followed by thoracic and lumbar curves. **Conclusion:** The prevalence of idiopathic scoliosis among 11-year-old Korean adolescents was 0.19%.

Key Words: Idiopathic scoliosis, 11-year-old adolescents, prevalence, Korea

INTRODUCTION

Clinical deformity of either a rib hump or asymmetric waist crease and back pain are correlated with idiopathic scoliosis, according to recent reports;¹⁻³ nevertheless, an association of back pain with scoliosis remains controversial.⁴ School screening enables early detection and early institution of conservative treatment, with the purpose of reducing the number of patients requiring surgical treatment.⁴⁻⁶ The optimal age for scoliosis screening is still under debate.⁷ Children between 10 and 14 years old are considered as good candidates for school screening tests of scoliosis, as an increased prevalence thereof has been noted with pubertal growth spurts.⁸ The prevalence of idiopathic scoliosis also increases as the age of a screened population increases.⁹⁻¹¹ Therefore, screening might be more effective at a younger age, and some have reported that ages between 11 and 12 may be the most appropriate

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for school screening tests.⁷ These differences in 1-2 years can often mean the difference between operative and braceable deformities because of the rapid progression of curves associated with pubertal growth spurts.

In Korea, the prevalence of scoliosis was 5.57% in 10 to 12-year-old girls and 2.37% in 10 to 12-year-old boys in a cross-sectional population study performed in 2011.¹² However, there have been no large-scale studies regarding the prevalence of idiopathic scoliosis in 11-year-old Korean adolescents. Therefore, the authors performed a 3-year epidemiologic study on 37856 11-year-old Korean adolescents to determine the prevalence, gender prevalence, curve magnitude, and patterns of idiopathic scoliosis.

MATERIALS AND METHODS

A total of 37856 (17110 females and 20746 males) adolescents were screened out of 11 year-old adolescents residing in Ulsan, a metropolitan city in Korea, from 2004 to 2006

(Table 1). The screening was performed in two stages: Initially, Moiré topography was performed to identify patients with changes in spinal curvature; this method has become an accepted method for screening scoliosis.¹³ Moiré topography is a method for identifying the curvature of spinal column according to morphology of the contour of back of the patient, which is formed by a circular light projected from 1.57 m from the subject. A midline is drawn on the Moiré image of the back, and the Moiré fringe difference of the two halves of the trunk is compared. Moiré fringe difference of less than one contour line between both sides is considered as normal (Fig. 1) and more than 1.5 contour lines confirms the presence of referral criteria (Fig. 2). Asymmetry of lateral lines of the back and waist or bulged flank is also considered positive findings of Moiré topography (Fig. 3). In the second step, lateral radiographs of the whole spine while standing were taken when the initial Moiré topography showed positive results. We defined idiopathic scoliosis as a Cobb's angle of greater than 10° on whole spine lateral radiographs. This study was approved by our Institutional Review Board.

Table 1. Number of Adolescents Enrolled for the Current Study and the Prevalence of Scoliosis According to Sex

Yr	Number of adolescent			Number of scoliotic patients (percentage)		
	Male	Female	Total	Male (%)	Female (%)	Total (%)
2004	10204	8317	18521	10 (0.01)	47 (0.57)	57 (0.31)
2005	3897	3217	7114	1 (0.03)	5 (0.16)	6 (0.08)
2006	6645	5576	12221	0 (0.00)	8 (0.14)	8 (0.07)
Total	20746	17110	37856	11 (0.05)	60 (0.35)	71 (0.19)



Fig. 1. Moiré topography of a normal back.

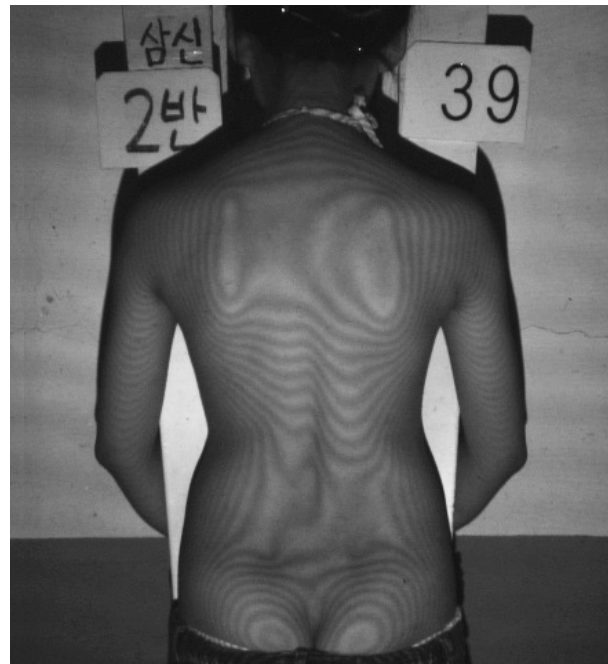


Fig. 2. Moiré fringe difference of more than 1.5 contour lines confirms the presence of referral criteria.

RESULTS

Moiré topography and radiographs

A total of 204 patients (1.1%) were found to be positive on Moiré topography among 37856 candidates. Among the 204 patients, 71 (0.19%) had scoliotic deformity of more than 10° (Table 1). The prevalence in the male population was 0.05% (11 out of 20746), and that in the female population was 0.35% (60 out of 17110). The average age, weight, and height of study population were 11.5±0.3 years old, 38.9±10.8 kg, and 146.2±15.3 cm, respectively. The average age, weight, and height of adolescents with idiopathic scoliosis were 11.4±0.4 years old, 39.0±11.3 kg, and 145.6±14.7 cm, respectively. The false positive rate of Moiré topography was 65.2% (133 out of 204 cases).

Magnitudes of curvature

The magnitude of the scoliotic curvature was measured by Cobb's angle; 53 candidates (0.14%) were between 10° to 19°, 15 candidates (0.04%) were between 20° to 29°, and three candidates (0.01%) were between 30° and 39°. The male to female ratio was 1:3.8 in the 10-19° scoliotic group, whereas other groups consisted of only females (Table 2). The overall ratio of boys to girls was 1:5.5.

Patterns of curvature

Sixty adolescents (84.5%) exhibited a single curvature and 11 (15.5%) had double curvatures (Table 3). In the single curve group, 43 adolescents (60.5%) had a thoracolumbar curve, 13 (18.4%) had a thoracic curve, and four (5.6%)

had a lumbar curve. Thirty-seven adolescents (52.1%) exhibited curvature convex toward the right side and 34 candidates (47.9%) showed the same to the left side.

DISCUSSION

The prevalence of scoliosis of 10° or greater in previous studies ranged from 0.1% to 3.2%, depending on age, sex, and geographic location (Table 4).^{5,6,10,14-20} In Greece, the prevalence of idiopathic scoliosis increased with age in the screened population: 0.07% in the 9-year-old group, 0.20% in 10-year-old group, and up to 0.40% in 14-year-olds.⁹ In England, the prevalence rates were 0.1% at 6 to 8 years of age, 0.3% at 9 to 11 years of age, and 1.2% at 12 to 14 years of age.¹⁰ In Singapore, the prevalence rates for girls were 0.05% at 6 to 7 years of age, 0.24% at 9 to 10 years of age, 1.37% at 11 to 12 years of age, and 2.22% at 13 to 14 years of age.¹¹

In Korea, the prevalence of scoliosis of 10° or greater was recently reported as 5.57% in 10 to 12-year-old girls and

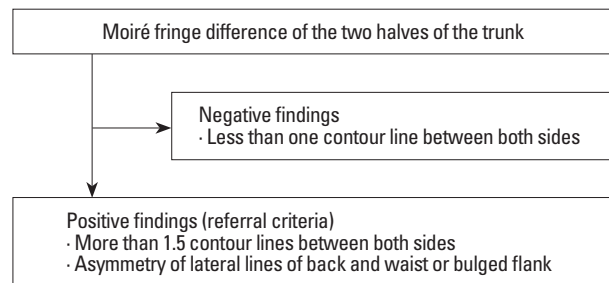


Fig. 3. Flow diagram of Moiré topography.

Table 2. Magnitude and Male to Female Ratio of the Scoliotic Curves Exceeding 10°

Magnitudes	Number of scoliotic patients			Male/female ratio
	Male	Female	Total (%)	
10-19°	11	42	53 (0.14)	1:3.8
20-29°	0	15	15 (0.04)	
30-39°	0	3	3 (0.01)	
Total	11	60	71 (0.19)	1:5.5

Table 3. Distribution of the Patterns and Convexity of the Scoliosis Curves Exceeding 10°

Curve pattern	Convexity		Total (%)
	Right	Left	
Single curves	32	28	60 (84.5)
Thoracic	10	3	13 (18.4)
Thoracolumbar	21	22	43 (60.5)
Lumbar	1	3	4 (5.6)
Double curves	5	6	11 (15.5)
Total (%)	37 (52.1)	34 (47.9)	71 (100)

2.37% in 10 to 12-year-old boys.¹² However, there have been no large-scale studies regarding the prevalence of idiopathic scoliosis in 11-year-old adolescents in Korea. Therefore, we performed a 3-year epidemiologic study on 37856 eleven year-old Korean adolescents to determine the prevalence of idiopathic scoliosis, gender prevalence, curve magnitude, and patterns thereof.

In the current study, the prevalence of scoliosis in the population of 11-year-old Korean adolescents was 0.19%. The prevalence in the male population was 0.05% and that in the female population was 0.35%. The ratio of male to female was 1:5.5 overall. The prevalence of idiopathic scoliosis of 11-year-old adolescents was reported to be 0.04% to 1.1% in boys and 0.78% to 4.6% in girls in Athens, Singapore, and Tokyo (Table 4).^{11,21,22} The prevalence rates in the current study differed over the years. There was a difference in the numbers of screened adolescents over the years, which may be a confounding factor. The prevalences of scoliosis in the male and female population of 11-year-old Korean adolescents were similar with those in Tokyo (Table 4).²² The male to female ratio of idiopathic scoliosis in 11-year-olds in the current study was also similar with studies on

11-year-olds in Singapore and Tokyo (Table 5).^{11,22}

In current study, thoracolumbar curves were the most common, followed by thoracic and lumbar curves. In general, a single curve pattern is thought to be more common than double curves.^{11,15,19,23} The most common type of curvature is reported to be a single thoracolumbar curve, followed by lumbar and thoracic curves.^{19,23} In the study on 11-year-olds in Singapore, the most common type of curvature was reported to be single thoracolumbar curve, followed by thoracic curve and lumbar curve.¹¹ Participants in the current study showed similar results with previous reports.¹¹ However, in the study on 10 to 12-year-olds in Korea, the most common type of curvature was reported to be thoracic curve, followed by thoracolumbar/lumbar curve.¹² Adam's forward bending test was used as the initial screening test in the previous studies of 9 to 14-year-olds in Greece¹⁹ and in 11-year-olds in Singapore,¹¹ in which the most common type of curvature was thoracolumbar curve. Also, Adam's forward bending test was the initial screening test for 10 to 12-year-olds in Korea,¹² in which the most common type of curvature was a thoracic curve. Nevertheless, we do not think that the difference in most common type of curvature

Table 4. Comparison of Idiopathic Scoliosis Based on Data from Previous Studies

	Yr	Place	Criteria (°)	Age	Population	Prevalence (%)	Male/female ratio	Screening test
Dickson, et al. ¹⁵	1980	England	10	10 to 14	5303	2.0	1:2.7	Topography
Lonstein, et al. ⁶	1982	USA	10	10 to 14	1473697	1.2		Bending test
Willner and Udén ²⁰	1982	Sweden	10	7 to 16	17181	3.2 (girls), 0.5 (boys)		Bending test
Morais, et al. ¹⁸	1985	Canada	10	8 to 15	29195	1.8	1:2.1	Bending test
Stirling, et al. ¹⁰	1996	England	10	9 to 11	15799	0.4 (girls), 0.1 (boys)	1:4.9	Bending test
Soucacos, et al. ¹⁹	1997	Greece	10	9 to 14	82900	2.6 (girls), 0.9 (boys)	1:3.0	Bending test
Karachalios, et al. ¹⁷	1999	Greece	10	8 to 16	2700	1.18		Bending test/topography
Grivas, et al. ¹⁶	2002	Greece	10	5.5 to 15	215899	2.9	1:2.3	Bending test
Adobor, et al. ¹⁴	2011	Norway	10	12	4000	0.55	1:2.7	Bending test
Smyrnis, et al. ²¹	1979	Athens	10	11 to 12	3494	4.6 (girls), 1.1 (boys)	1:4.2	Bending test
Wong, et al. ¹¹	2005	Singapore	10	11 to 12	18101	1.3 (girls), 0.2 (boys)	1:6.0	Bending test
Ueno, et al. ²²	2011	Tokyo	10	11 to 12	137562	0.78 (girls), 0.04 (boys)	1:18.1	Topography
Current study	2004 to 2006	Ulsan	10	11	37856	0.35 (girls), 0.05 (boys)	1:5.5	Topography

Table 5. Comparison of the Magnitude and Male to Female Ratio of Scoliosis among 11-Year-Olds from Previous Studies

Magnitudes	Wong, et al. ¹¹			Ueno, et al. ²²			Current study		
	Number of patients		Male/female ratio	Number of patients		Male/female ratio	Number of patients		Male/female ratio
	Male	Female		Male	Female		Male	Female	
10-19°	18	69	1:3.8	31	526	1:17.0	11	42	1:3.8
20-29°	2	32	1:16	8	181	1:22.6	0	15	
Above 30°	0	18					0	3	
Total	20	119	1:6.0	39	707	1:18.1	11	60	1:5.5

between the previous Korean study and the current study relates to the initial screening test of Moiré topography.

Most studies for the prevalence of scoliosis used the Adam's forward bending test as the initial screening test, and three studies used the Moiré topography (Table 4). Adam's forward bending test is widely used as the initial screening test for school screening; however, it reportedly yields a high number of false-negative results and cannot be safely used as a single screening tool for scoliosis.¹⁷ Adam's forward bending test generated five false-negative results in 153 patients with scoliosis out of 2700 adolescent screened for scoliosis and 54 false-positive results with a sensitivity of 84.4% and a specificity of 93.4%.¹⁷ Moiré topography showed no false-negative results in the same study population and 269 false-positive results with a sensitivity of 100% and a specificity of 85.4%.¹⁷ Moiré topography was used as the initial test for school screening in this study. This test is a photostereometric method used to determine imbalances in body surface by acquiring three-dimensional images of the body.^{24,25} It has a high sensitivity.²⁴ Moiré topography has false positive rate of 25% to 70%.^{24,26} False positives arise when the subject is not placed horizontally to the light as the circular light is projected.^{26,27} Therefore, subjects must be positioned in the correct posture and maintain contact of their shoulders and hips with the exam table.^{26,27} False negative results of Moiré topography are reported to occur in 0% to 4.3%.^{17,25} Notwithstanding, it might be unreasonable to generate harmful radiographs for every patient with a negative result on Moiré topography.

Assessing Moiré topography is quite easy and convenient as it utilizes small and portable devices, although it is expensive, compared with an inclinometer. Accordingly, in terms of cost, there are controversies concerning scoliosis screening programs. The cost of a scoliosis screening program for 1473697 adolescents in Minnesota in 1982 was low, averaging 6.6 cents per student screened.⁶ Among 115190 adolescents in Hong Kong in 2010, the costs of screening and diagnosing a child with a scoliosis were \$17.94 and \$2.08, respectively.²⁸ Both studies concluded that their scoliosis screening program was cost effective.^{6,28} However, the average cost of finding one child with a scoliosis of 5 degrees or more was \$194 in the scoliosis screening program of 29195 adolescents in Quebec, Canada in 1985.¹⁸ Morais, et al.¹⁸ concluded that the scoliosis screening program in Quebec was not a cost effective program. Also, there are controversies about the efficacy of brace treatment for idiopathic scoliosis. Nevertheless, systematic reviews of the efficacy

of brace treatment for idiopathic scoliosis support bracing's ability to prevent curve progression of 6 degrees, but not for preventing surgery.²⁹

As with any study, the present investigation may have some potential problems. Ideally, a larger population should have been screened. Secondly, there was a difference in the number of screened 11-years-olds over the 3-year study period, which may act as an important confounding factor. Thirdly, all adolescents negative on Moiré topography had the possibility of spinal deformity, because there were 4.3% false negatives for Moiré topography.²⁵ Finally, adolescents with scoliosis whose curve progressed as the age of 12 years old may be overlooked when the age for scoliosis screening was set at 11 years. This might be the reason why the prevalence of 0.19% in 11-year-old Korean adolescents was lower than the prevalences of scoliosis of 5.57% in 10 to 12-year-old girls and 2.37% in 10 to 12-year-old boys in a previous cross-sectional population study performed in 2011 in Korea.¹² It is best to perform Moiré topography twice, once at ages 11 and 14 years, despite problems with cost, time and effort.

In conclusion, the prevalence of idiopathic scoliosis was 0.19% among 11-year-old Korean adolescents. This is the first study to report the prevalence of idiopathic scoliosis in 11-year-old adolescents in Korea.

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