

# The Prediction of Curve Progression in Untreated Idiopathic Scoliosis during Growth\*†

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**ABSTRACT:** We reviewed the cases of 727 patients with idiopathic scoliosis in whom the initial curve measured from 5 to 29 degrees. The patients were followed either to the end of skeletal growth or until the curve progressed. One hundred and sixty-nine patients (23.2 per cent) showed progression of the curve. The incidence of curve progression was found to be related to the pattern and magnitude of the curve, the patient's age at presentation, the Risser sign, and the patient's menarchal status. We found no correlation between progression of the curve and the patient's sex, Harrington factor, rotational prominence, family history, or radiographic measurements. A progression factor was calculated using the three strongest correlations available at initial examination: the magnitude of the curve, the Risser sign, and the patient's chronological age. A graph and nomogram are presented that can serve as a guide for advising patients' families and for planning continuing care.

With the institution and increasing use of school-screening for the early detection of spinal deformities, a large number of patients with idiopathic scoliosis but a minimum curve are being referred to the pediatrician, family practitioner, or orthopaedic surgeon for care. A knowledge of the factors that influence the prognosis in idiopathic scoliosis is therefore essential in evaluating these patients and in planning an intelligent and rational treatment program.

Three important questions regarding prognosis need to be answered: (1) How many of these minimum curves will progress; that is, what is the incidence of progression? (2) What identifiable factors are related to progression of the curve? (3) Is it possible to use these factors to predict which curve will progress and which will not? Only if these questions can be answered can a rational treatment plan be formulated.

## Literature Review

Few investigators have reviewed the prognosis of untreated mild idiopathic scoliosis. Duval-Beaupère pointed

out that the progression of idiopathic scoliosis occurs at the time of the most rapid adolescent skeletal growth, although the exact incidence of progression has varied greatly in different reported series. Brooks et al., in a review of 134 patients with untreated curves that were initially detected by school-screening who were followed for an average of twenty-one months, found that although 5.2 per cent of the curves increased by 5 or more degrees, 22.4 per cent decreased by the same amount. Clarisse reported on 110 patients with idiopathic scoliosis who were followed during growth and whose initial curve measured between 10 and 29 degrees. Without treatment, 35 per cent of these curves progressed. Rogala et al., in their review of a school-screening program, followed 603 children for a minimum of two years and found that 6.8 per cent had progression of the curve; 2.1 per cent of the curves that were initially less than 10 degrees progressed, compared with 10.3 per cent of the curves that were initially greater than 10 degrees; and of fifty-two skeletally immature patients whose curve was initially between 20 and 30 degrees, 78.8 per cent had progression. Fustier reviewed the cases of 100 patients whose initial curve was less than 45 degrees; of seventy children whose curve was initially less than 30 degrees, 56 per cent had progression. Bunnell, in a recent review of the cases of 326 patients, showed that of the curves that were initially between 20 and 30 degrees, 20 per cent showed progression. The authors of three of the cited series calculated the rate of progression for different curve patterns (Table I).

There has been fairly good agreement in the literature concerning the factors that appear to be related to curve progression in idiopathic scoliosis: the pattern of the curve<sup>3,4,6</sup>, age<sup>3,4</sup>, and maturity as determined by whether or not menarche has been reached<sup>3,4</sup> and the Risser sign. The factors that have not been proved to be related to progression are the flexibility of the curve<sup>4</sup>, sagittal deformity, lumbosacral abnormalities, and alignment of the trunk<sup>3</sup>. Other factors are still controversial, in that some studies have shown a relationship between progression and the patient's sex<sup>3,4,13</sup>, family history<sup>3,13</sup>, and magnitude of the curve<sup>3,4,6,13</sup>, while other studies have not.

It obviously would be very beneficial if the treating physician could accurately predict which curves will progress, and various approaches have been tried. Schultz et al. proposed that the morphology of the spine is related to progression, in that relative slenderness of the spine was more common in progressive curves. Redford et al., using electromyography of the paraspinal muscles, reported a dif-

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TABLE I  
INCIDENCE OF CURVE PROGRESSION IN THREE REPORTED SERIES

Series	No. of Patients	Range of Magnitude of the Curves (Degrees)	Percentage of Curves that Progressed			
			Double	Thoracolumbar	Thoracic	Lumbar
Clarisse	110	10-29	67	47	42	12
Fustier	100	< 45	75	69	54	25
Bunnell	326	9-100	27	27	44	18

ference in the findings between progressive and non-progressive curves. Ponte proposed using specific values for rotational prominence as a determinant of progression, and Armstrong et al. stated that non-standard vertebral rotation (rotation of the spinous process to the convexity of the curve) is related to a low risk of progression. Each of these studies, however, consisted of a single report, and no subsequent confirming studies have been published.

### Materials and Methods

To investigate the factors that are related to progression of idiopathic scoliosis and the intriguing possibility of being able to use them to predict the prognosis in a specific patient, a study was undertaken at the Twin Cities Scoliosis Center (Fairview Hospital, Minneapolis, and Gillette Children's Hospital, St. Paul, Minnesota). The information on all juvenile and adolescent patients with idiopathic scoliosis who were seen between 1970 and 1979 was reviewed using the computerized data-base maintained at the Center. The criteria for inclusion in the study were: (1) a diagnosis of idiopathic scoliosis, (2) an initial standing anteroposterior or posteroanterior radiograph showing scoliosis of 29 degrees or less, and (3) follow-up to skeletal maturity as shown by a Risser sign of 5 or until progression of the curve had occurred.

An accurate definition of progression is important. Some authors have defined it as a 5-degree<sup>2,4,6</sup> or 10-degree<sup>3</sup>

increase in a curve, irrespective of the magnitude of the curve. In this series a clinical definition was employed, using the same criteria as those used to institute a non-operative treatment program such as bracing or transcutaneous electrical stimulation. The criteria for progression were: (1) an initial curve of 19 degrees or less that increased at least 10 degrees, with the final curve being greater than 20 degrees (for example, a 15-degree curve that increased to 25 degrees or a 7-degree curve that increased to 20 degrees), and (2) an initial curve of between 20 and 29 degrees that increased by 5 degrees or more.

A total of 727 patients fulfilled these criteria. The majority of the patients were initially seen between 1974 and 1979, as a result of the Minnesota statewide school-screening project<sup>7</sup>. There were 575 girls (79 per cent) and 152 boys (21 per cent). Three hundred and thirty-eight (59 per cent) of the girls had passed the menarche by the time of the first evaluation. The distribution of the chronological ages of the total group is shown in Figure 1.

The chart and radiographs were reviewed for each patient, noting sex, age at first visit, curve pattern, menarchal status at first visit, curve magnitude, Risser sign, and length of follow-up. Multiple measurements were made on the radiographs for biomechanical analysis (Figs. 2-A and 2-B). The initial standing anteroposterior radiograph was evaluated. The curve pattern was classified as single (thoracic, thoracolumbar, or lumbar), double (double thoracic, double

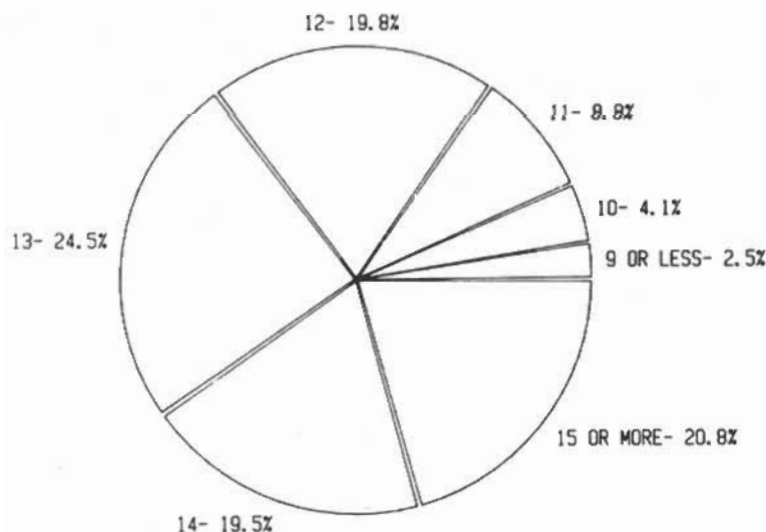


FIG. 1

Distribution of the ages of the 727 patients.

thoracic and thoracolumbar, or double thoracic and lumbar), or multiple (three curves or more). When there was more than one curve no effort was made to differentiate major from the compensatory curves; all of them were considered in the classification of the curve pattern. The distribution of curve patterns in the total group is shown in Figure 3.

The magnitude of the initial curve was measured (when multiple curves were present, the magnitude of the largest one was used), and the magnitudes were divided into 5-degree groups (Fig. 4). The distribution of the Risser sign in the 727 patients is shown in Figure 5. The information on the total population was analyzed, and the patients were divided into two subgroups: those who showed progression of the curve and those who did not. We then compared the subgroups using computer analysis of single or multiple factors, mathematical interrelations, or biomechanical fac-

tors singly or in combination, to determine if any of these analyses could predict which curves would progress.

## Results

### Progression of the Curves

One hundred and sixty-nine (23.2 per cent) of the 727 patients had progression of the curve. Seventy-eight (10.7 per cent) showed an improvement in the curve of 5 degrees or more between the initial visit and the final follow-up. When compared with the total group, the patients who had improvement were less mature (57 compared with 40 per cent had a Risser sign of zero) and a larger percentage had a curve of less than 15 degrees (53 compared with 37 per cent). Only two patients whose initial curve was less than 5 degrees had progression, both to more than 20 degrees and both requiring bracing. Only 131 (78 per cent) of the

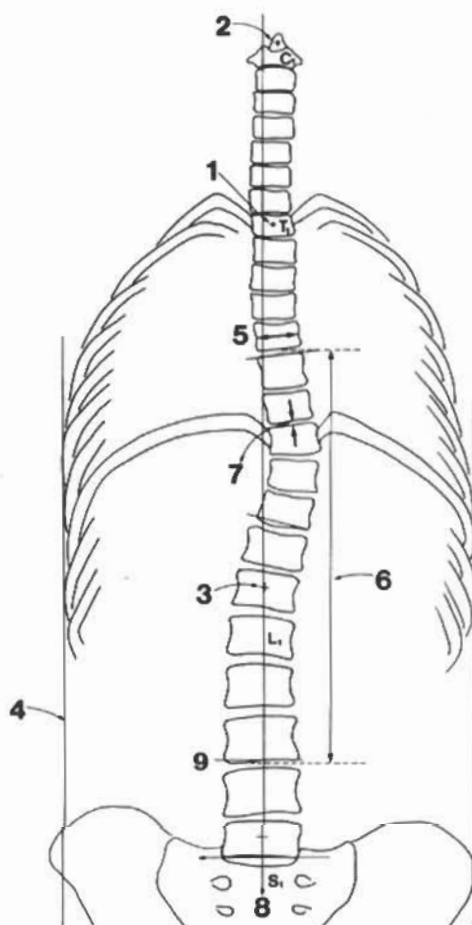


FIG. 2-A

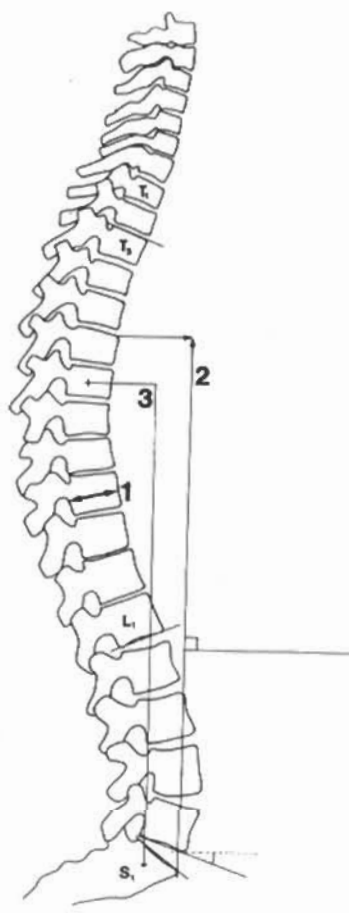


FIG. 2-B

Figs. 2-A and 2-B: The following equations were calculated at the fifth thoracic, tenth thoracic, and third lumbar vertebral levels:  $F^2/L^2$ ;  $F^3S/L^2$ , and  $F/L$ .

Fig. 2-A: Measurements made on the anteroposterior radiograph. 1. Horizontal distance from the center of the first thoracic vertebra to the vertical plumb line. 2. Horizontal distance from the center of the first cervical vertebra to the vertical plumb line. 3. Horizontal distance from the center of the twelfth thoracic vertebra to the vertical plumb line. 4. Relationship between a vertical line drawn down the lateral thoracic margin and the lateral margin of the ilium. 5. (F) Frontal diameter of the middle of the vertebral body measured at the fifth and tenth thoracic and third lumbar vertebrae. 6. (L) Vertical distance from the middle of the inferior plate of the fifth thoracic vertebra to the middle of the inferior plate of the third lumbar vertebra. 7. Vertical thickness of the discs between the seventh and eighth thoracic, eighth and ninth thoracic, second and third lumbar, and third and fourth lumbar vertebrae. 8. Lateral deviation from the midline of the middle of the seventh thoracic vertebra: the apex of the thoracic curve and the apex of the lumbar curve. 9. Angle of tilt from the horizontal of the inferior plate of the third lumbar vertebra. 10. Mehta angle measured at the apex of the thoracic curve.

Fig. 2-B: Measurements made on the lateral radiograph. 1. (S) Sagittal diameter of the vertebral body measured at the inferior half of the fifth and tenth thoracic and third lumbar vertebrae. 2. Position of the superoanterior border of the sixth thoracic vertebra with respect to the superoanterior border of the first sacral vertebra. 3. Deviation of the center of the seventh thoracic vertebra from a vertical line drawn through the center of the first sacral vertebra.

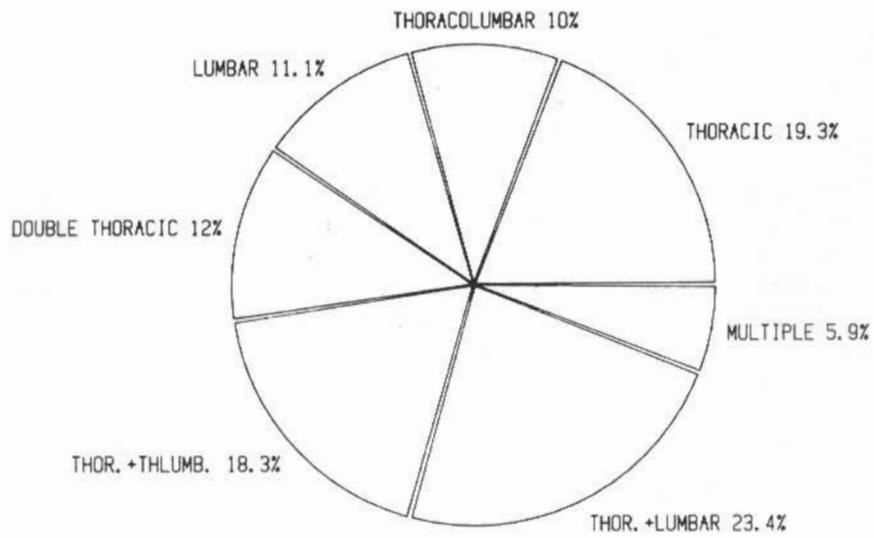


FIG. 3  
Distribution of the patterns of the curves in the 727 patients.

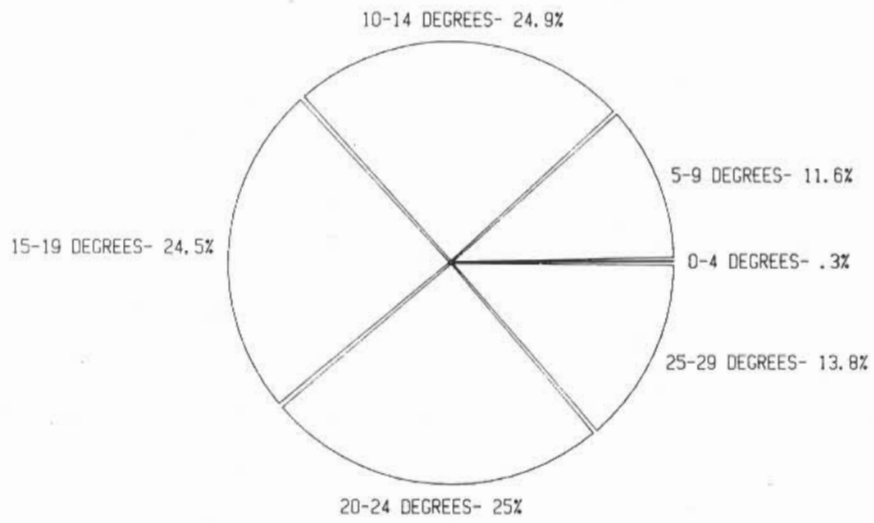


FIG. 4  
Distribution of the magnitudes of the curves, in 5-degree groupings, in the 727 patients.

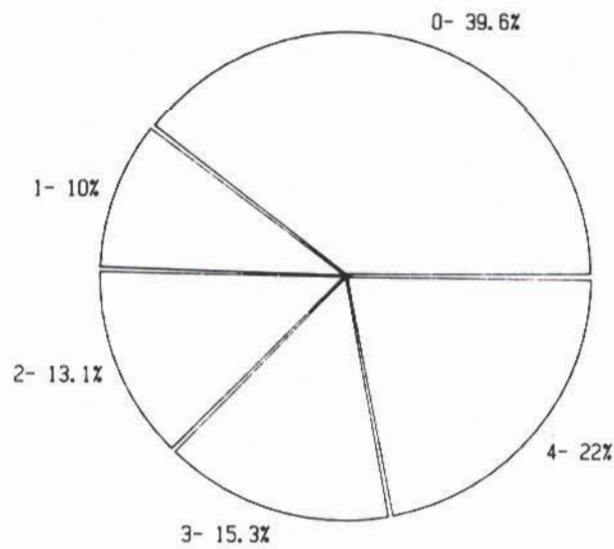


FIG. 5  
Distribution of the Risser signs in the 727 patients.

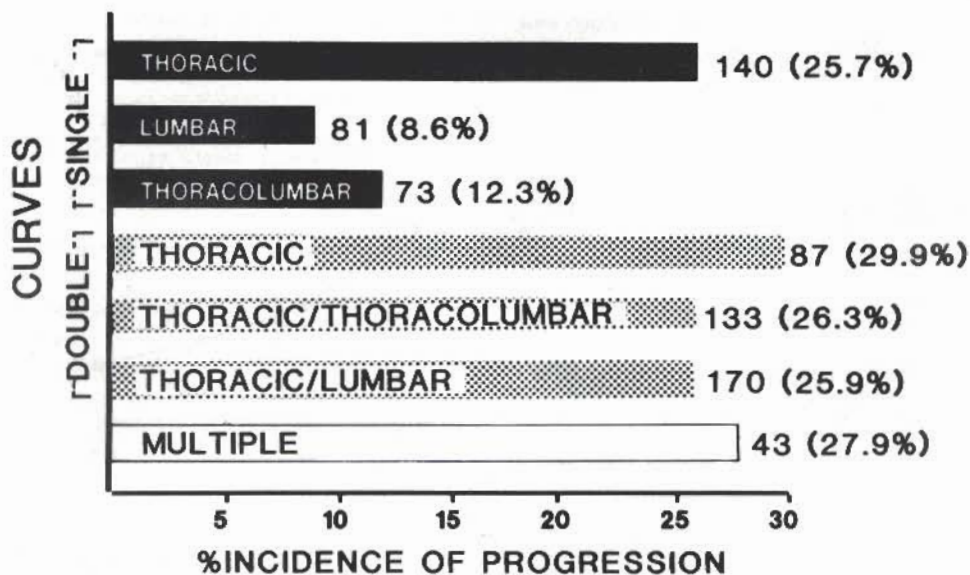


FIG. 6

The incidence of progression for each of the curve patterns. The numbers to the right of the bars indicate the numbers of patients with each pattern, and the numbers in parentheses indicate the percentages that progressed.

169 patients whose curve progressed were actively treated. Eighty-five wore a Milwaukee brace (cervicothoracolumbosacral orthosis); thirty-five wore an underarm (thoracolumbosacral) orthosis; ten had electrical stimulation; and one had surgical treatment. Although the curves of the remaining thirty-eight patients showed progression, they did so at a very slow rate, and the compensated curves were less than 40 degrees at skeletal maturity, so no treatment was necessary. Thus, only 131 (18 per cent) of the 727 patients required treatment. The range of follow-up for the patients whose curves did not progress was twelve to eighty-eight months (average, 25.5 months) and for those whose curves did progress the range was three to eighty-four months (average, 13.6 months). If the thirty-eight patients

who were not treated are excluded, the range of follow-up for the curves that progressed and required treatment was three to eighty-four months (average, 11.9 months). The rate of progression for the curves that did not require treatment was 0.3 degree per month, while it was 0.8 degree per month for the curves that progressed and required treatment. In addition, the patients whose curves progressed but did not require treatment were more mature than those who required treatment (55 per cent compared with 17 per cent had a Risser sign of 2, 3, or 4), and they had a larger average initial curve (28 compared with 17 degrees).

Single Factors

Sex: Twenty-seven boys (18 per cent) and 142 girls

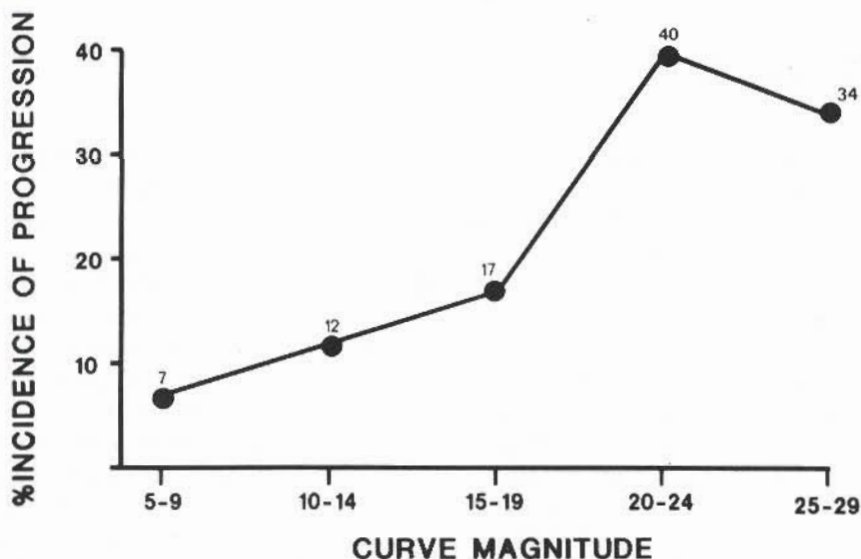


FIG. 7

Graph showing the incidence of progression related to the magnitude of the curve. There is a marked increase in the incidence of progression for the curves between 20 and 29 degrees. The numbers next to the data points indicate the per cent of curves that progressed.

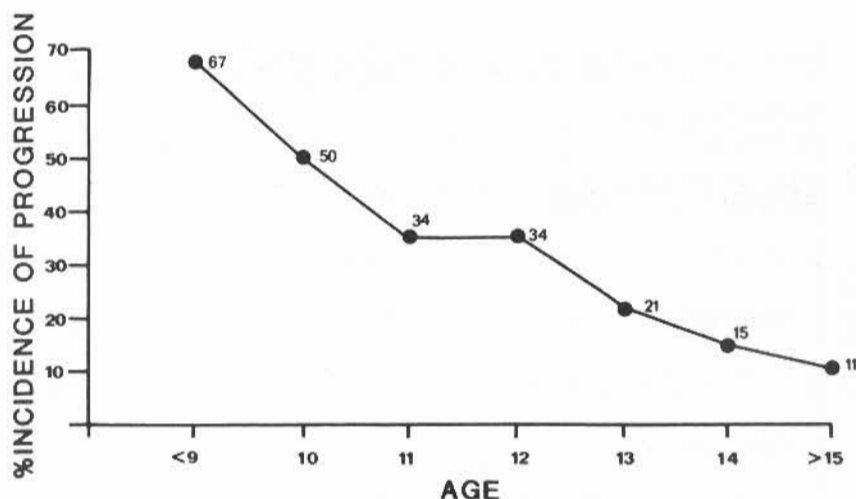


FIG. 8

Graph showing the incidence of curve progression related to the age of the child when first seen. The incidence gradually decreased as the patients' ages increased. The numbers next to the data points indicate the per cent of curves that progressed.

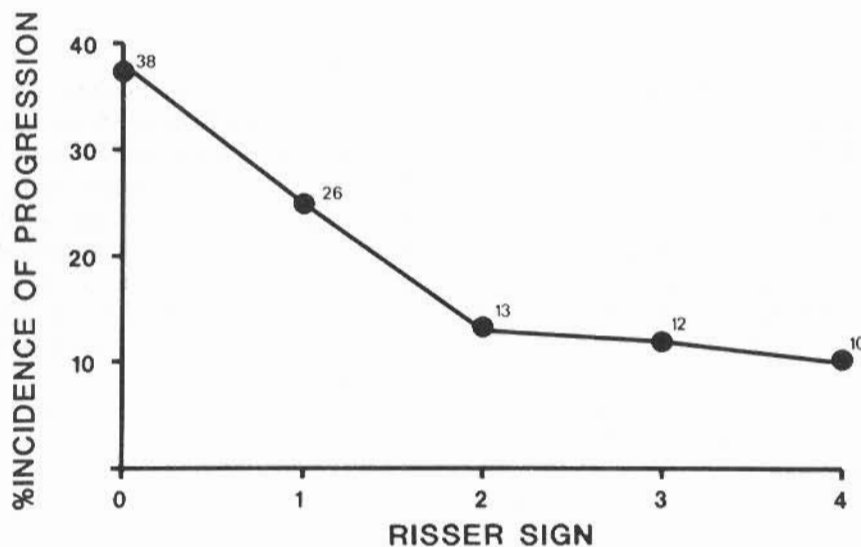


FIG. 9

Graph showing the incidence of curve progression related to the patient's Risser sign when first seen. The incidence markedly decreased when the Risser sign was 2 or more. The numbers next to the data points indicate the per cent of curves that progressed.

(25 per cent) showed progression of the curve. This difference was not statistically significant.

**Curve pattern:** The incidence of progression was found to differ for the different curve patterns, with more double curves progressing (27 per cent) than single curves (17.6 per cent) (Fig. 6). With double curves, the question must be asked: is progression more likely to occur in one or both curves? In the forty-four patients with a double thoracic and lumbar curve that progressed, the thoracic component progressed in eleven (25 per cent); the lumbar component, in nineteen (43 per cent); and both components, in fourteen (32 per cent). In the thirty-five patients with a double thoracic and thoracolumbar curve, the thoracic component progressed in eleven (31 per cent); the thoracolumbar component, in fourteen (40 per cent); and both components, in ten (29 per cent).

**Magnitude of the curve:** The greater the magnitude of the initial curve, the more likely it was to progress (Fig. 7). There was a threefold increase in the percentage of patients who had progression when the initial curve was greater than 20 degrees. The average initial non-progressive curve was 15 degrees, compared with an average initial progressive curve of 19.7 degrees.

**Age:** The incidence of progression decreased with increasing chronological age (Fig. 8). However, it was not possible to correlate progression with bone age because an insufficient number of patients had had the radiograph of the hand that is required for determination of bone age.

**Risser sign:** The incidence of curve progression decreased as the initial Risser sign increased (Fig. 9). Thirty-six per cent of the patients with a Risser sign of zero or 1 had progression of the curve, whereas 11 per cent of the

TABLE II  
INCIDENCE OF PROGRESSION AS RELATED TO THE  
MAGNITUDE OF THE CURVE AND THE RISSER SIGN

Risser Sign	Percentage of Curves that Progressed	
	5 to 19-Degree Curves	20 to 29-Degree Curves
Grade 0 or 1	22	68
Grade 2, 3, or 4	1.6	23

patients whose Risser sign was 2, 3, or 4 had progression.

*Menses:* Information as to whether or not menarche had occurred by the time of the initial visit was available for 647 (89 per cent) of the girls in the study. Menarche had occurred in 379 (68 per cent) of the girls with a non-progressive curve but in only fifty-four (32 per cent) of those with a progressive curve.

*Harrington factor:* The Harrington factor, which is calculated by dividing the magnitude of the curve by the number of vertebrae in the curve, was determined for all curves at the patient's initial visit. It averaged 2.7 in the non-progressive curves and 3.4 in the progressive curves. This difference correlated with the slight difference between the average initial curve in the two groups.

*Rotational prominence:* The rotational prominence was determined for the different curve patterns, and then compared for the progressive and non-progressive curves. No significant difference was found.

*Family history:* The incidence of scoliosis in a parent or sibling was compared in the progressive and non-progressive groups, and no significant difference was found.

#### Multiple Factors

Using the positive correlations that were found between progression of the curve and the pattern and magnitude of the curve, chronological age, the Risser sign, and the onset of menses, cross correlations were calculated in an attempt to determine if a combination or combinations of these fac-

tors could aid in the prediction of which curves would show significant progression and which would not.

*Risser sign and magnitude of the curve* (Table II): There was a greater incidence of progression of the curve in patients with an initial Risser sign of zero or 1 compared with those with a Risser sign of 2, 3, or 4. In addition, the incidence of progression was definitely less when the initial curve was 19 degrees or less than it was when the initial curve was 20 to 29 degrees. The curves of 19 degrees or

TABLE III  
INCIDENCE OF PROGRESSION AS RELATED TO THE MAGNITUDE  
OF THE CURVE AND THE AGE OF THE PATIENT WHEN FIRST SEEN

Age When First Seen (Yrs.)	Percentage of Curves that Progressed*	
	5 to 19-Degree Curves	20 to 29-Degree Curves
10 and younger	45 (38)	100† (10)
11 to 12	23 (147)	61 (61)
13 to 14	8 (201)	37 (119)
15 and older	4 (67)	16 (84)

\* Numbers in parentheses indicate the number of patients in each group.

† Note that this figure of 100 per cent is based on only ten patients.

less in patients with a Risser sign of 2, 3, or 4 had only a 1.6 per cent incidence of progression, while the curves of 20 to 29 degrees in patients with a Risser sign of zero or 1 showed a markedly increased incidence of progression of 68 per cent.

*Age when first seen and magnitude of the curve* (Table III): The incidence of progression as related to the magnitude of the curve and chronological age is shown in Figures 7 and 8. All of the curves of 20 degrees or more in children who were ten years old or younger when first seen showed progression, but these ten patients were a very small percentage of the total group. The patients were divided into the four age-categories of ten years old and younger, eleven

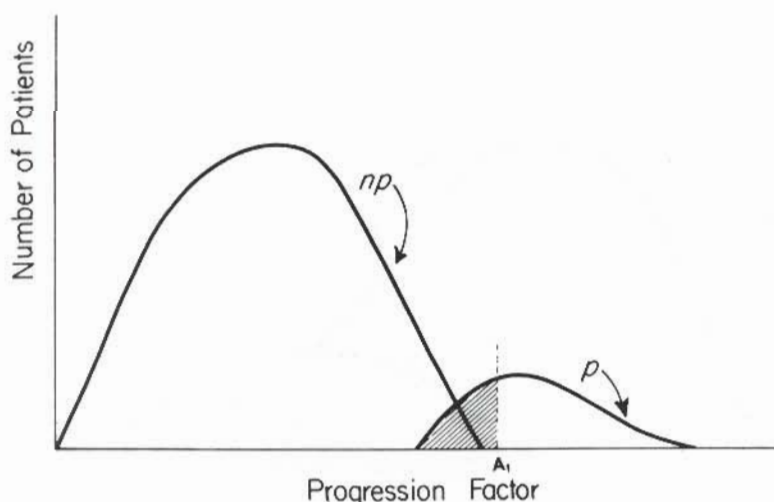


FIG. 10

Ideal graphs using a progression factor for prognosis of non-progressive (np) and progressive (p) curves. At a progression factor of  $A_1$ , the majority of the progressive curves were identified, with only a small number of false-negative predictions (shaded area).

and twelve, thirteen and fourteen, and fifteen and older, and the age was correlated with the magnitude of the curve (Table III). In a child who was twelve years old or younger an initial curve of 20 to 29 degrees had a 61 per cent chance of progression, while in one who was fifteen or older a curve of less than 19 degrees had a 4 per cent chance of progression.

The factors that showed a positive correlation with progression were analyzed in terms of individual curve patterns, as shown in Figures 7, 8, and 9. As the number of patients with some curve patterns was small, obviously those graphs were less characteristic.

#### Prognostication

We analyzed the described factors and the radiographic measurements both manually and with the aid of a computer. Prediction factors were developed and calculated for each patient to predict whether the curve would progress or not. The predicted outcome with each factor was then compared with the actual outcome. The cases of all of the patients were thus analyzed and a grid was obtained for each factor (Table IV). Four outcomes were possible: (1) the prediction of a progressive curve was correct; (2) the prediction of a non-progressive curve was correct; (3) the curve was predicted to be progressive, but actually was non-progressive (a false-positive outcome); and (4) the curve was predicted to be non-progressive, but actually was progressive (a false-negative result). Clinically, a false-negative prediction can be acceptable if the patient is followed and treated promptly when progression occurs. If treatment is based on a false-positive prediction, however, the patient may be over-treated by bracing a curve that would not have progressed without treatment.

When multiple factors, the biomechanical measurements, or formulae were used to predict progression, there was always a significant number of false-positive results.

However, if the value of the factors was changed to reduce the number of false-positive predictions, the number of false-negative predictions increased and the predictive ability was no better than that calculated by analyzing the simple relationships with age and the Risser sign (Tables II and III). This is due to the great variability that actually occurs in a clinical situation. An ideal predictive factor (Fig. 10) would be one with which, at value  $A_1$ , the majority of progressive curves would be identified, with only a small number of false-negative predictions. In actuality (Fig. 11), the two graphs overlap so that at point  $A_1$  only a small number of progressive curves are identified, and there are a large number of false-negative predictions. If a progression

TABLE IV  
GRID FOR COMPUTER EVALUATION OF THE  
INCIDENCE OF CURVE PROGRESSION

Actual Outcome	Computer Prediction of Outcome	
	Non-Progressive	Progressive
Non-progressive	Correct	False positive
Progressive	False negative	Correct

factor of  $B_1$  is used to increase the number of progressive curves that are identified, the number of false-positive predictions becomes even greater (Fig. 11). It appears that with the data available it is impossible to predict with total accuracy which curve will progress and which will not. It is possible to determine the likelihood of progression at the initial examination, but only in a very general manner (Tables II and III). We calculated a progression factor by using only those factors that had a high correlation with progression: the magnitude of the curve (Cobb angle), the Risser sign, and chronological age:

$$\text{Progression factor} = \frac{\text{Cobb angle} - 3 \times \text{Risser sign}}{\text{chronological age}}$$

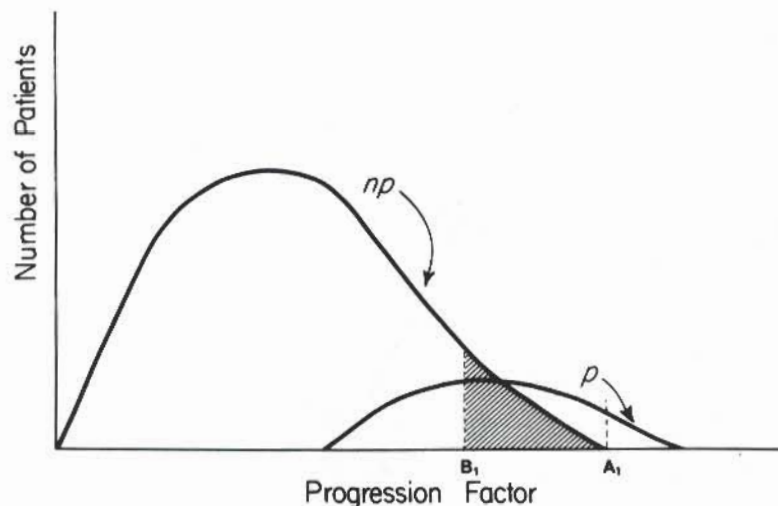


FIG. 11

Overlapping graphs obtained in this series, using a progression factor for prognosis of non-progressive (np) and progressive (p) curves. At a progression factor of  $A_1$  only a small number of progressive curves were identified, but if factor  $B_1$  was used to increase the number of progressive curves that were identified, there were a large number of false-positive results — that is, non-progressive curves that were classified as progressive (shaded area).

This progression factor was initially calculated for the curves that were between 20 and 29 degrees. For each progression factor the percentages of curves that progressed were used as data points to construct a curve (Fig. 12). The data points that indicated a low chance of progression were based on a large number of patients but those on the upper end of the curve were calculated from a small number of patients. When we used the same formula for curves of 19 degrees or less there was such a large scatter in the data points that it was impossible to draw an averaging curve.

Using the described data for curves between 20 and 29 degrees, we constructed a nomogram (Figs. 13-A and 13-B). Using the variables of Cobb measurement, Risser sign, and chronological age, the progression factor could be read from the graph as well as the percentage incidence of progression of the curves with that factor.

#### Discussion

School-screening has resulted in a large number of patients with minimum idiopathic scoliosis being seen for evaluation and treatment. A knowledge of the natural history of these curves is essential in planning a treatment program.

Our over-all incidence of curve progression of 23.2 per cent is similar to that of other published reports. As there was a great variability in the curves of the patients in the different series, however, comparisons are difficult. Also, the definition of progression, the ranges of the magnitudes of the curves, and the lengths of follow-up have all varied. As the incidence of progression depends on the location and pattern of the curve, the percentages are im-

portant (Table V). Except for the series of Ponseti and Friedman and that of Bunnell, the patients in the studies had minimum curves. This wide variation in the incidences of the different types of curves represents either a different definition of each curve pattern (especially double curves) or regional, ethnic, or genetic differences, another manifestation of the multifactorial nature of idiopathic scoliosis.

Seventy-eight (10.7 per cent) of the patients in our series showed spontaneous improvement over time without treatment, a finding that agrees with that of other studies. These patients tended to be less mature and to have smaller curves (less than 15 degrees) compared with the rest of the series. An unexpected finding was that thirty-eight of the 169 patients who had a progressive curve did not require treatment, as they were already skeletally mature when the progression was found. In addition, the rate of progression differed significantly in these 169 patients, with some curves showing slower progression, and the patients who did not require treatment were on the average more mature and had larger curves. It must be asked, however, whether these curves are really stable or whether they will show continued progression after the cessation of skeletal growth. Further follow-up and evaluation of these patients is planned.

Several factors definitely correlated with the incidence of progression. The four-to-one ratio of girls to boys in our total series differs from that in school-screening, indicating that fewer boys were referred for evaluation. Even though the incidence of progression in girls was only slightly higher than it was in boys (25 compared with 18 per cent), if this study had accurately represented the incidence in the screened school population a more significant difference

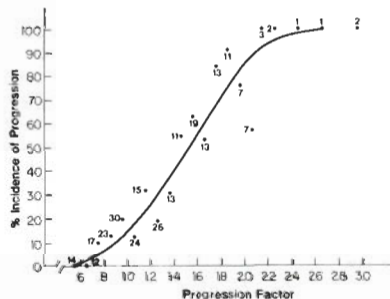


FIG. 12

Graph showing the incidence of progression according to the progression factor, which is calculated by the formula:

$$\text{Cobb angle} - 3 \times \text{Risser sign} \\ \text{chronological age}$$

for curves between 20 and 29 degrees. The numbers next to the data points indicate the number of curves that the data point is based on, and an averaging curve is drawn. Note that the data points at the upper end of the graph are based on a small number of curves.

TABLE V  
DISTRIBUTION OF CURVE PATTERNS IN SEVEN REPORTED SERIES

Series	No. of Patients	Curve Pattern (Per cent)			
		Thoracic	Lumbar	Thoracolumbar	Double
Ponseti and Friedman	335	22	26	16	36
Clarisse	110	28	39	14	19
Rogala et al.	1222	30	15	40	15
Fustier	100	25	25	17	33
Bunnell	326	43	8	16	35
Willner and Udén	474	44	12	31	13
Present series	727	31	11	10	48

might have been found.

There was a difference in the rates of progression as related to curve pattern, particularly in double curves, as has been described in other studies (Table I). The differences probably represent the different populations of these series as well as differences in the definition of specific patterns, especially the double pattern.

A definite relationship was found between the incidence of curve progression and three factors (Figs. 7, 8, and 9). There was a direct relationship between the incidence of progression and the magnitude of the curve, and an inverse relationship with chronological age and the Risser sign. The importance of chronological age was confirmed by the fact that 32 per cent of the girls with a progressive curve and 68 per cent of those with a non-progressive curve had reached menarche by the time of the first visit.

Other factors (Harrington factor, rotational prominence, and family history) did not correlate with the inci-

dence of progression. Multiple factors were analyzed (Tables II and III), and Table II shows that the clearest interrelation was with the Risser sign and curve magnitude. The figure for curves of more than 20 degrees in immature patients correlates with that of Rogala et al., who found that in an immature patient a curve between 20 and 30 degrees

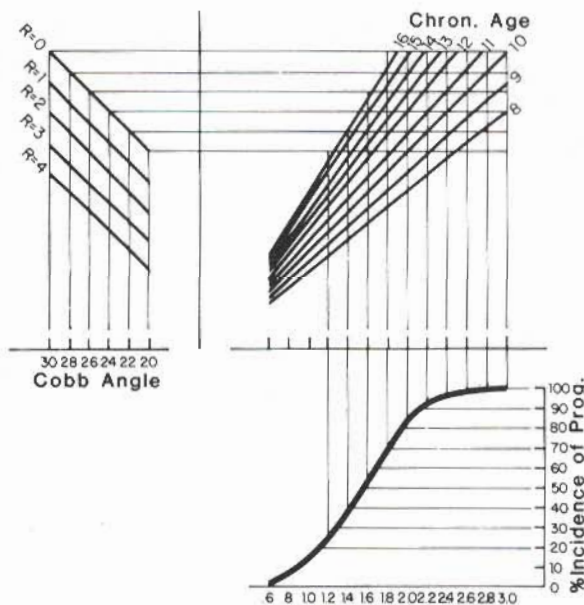


FIG. 13-A

Nomogram devised using the formula:

$$\text{progression factor} = \frac{\text{Cobb angle} - 3 \times \text{Risser sign}}{\text{chronological age}}$$

and the progression curve shown in Fig. 12.

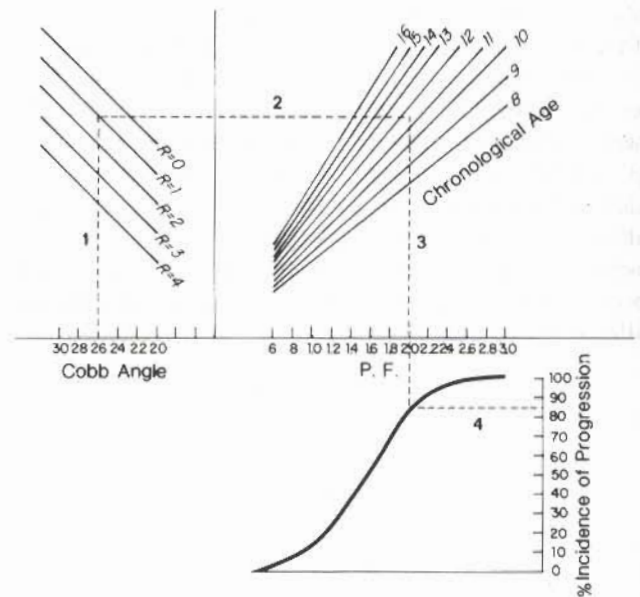


FIG. 13-B

Nomogram constructed for an eleven and one-half-year-old child with a 26-degree curve and a Risser sign of 1. A vertical line (1) is drawn from the Cobb angle to intercept the Risser-sign lines, and a horizontal line (2) is drawn from the intersection of this vertical line and Risser sign 1 (R=1). Another vertical line (3) is drawn from the intersection of line 2 and the chronological age of 11.5, and extended to intersect the progression-factor graph. At the intersection of line 3 and the graph curve, a horizontal line (4) is drawn to the incidence-of-progression axis and the value (85 per cent) is read off. This indicates that there is an 85 per cent chance that the curve will progress.

had a 78.8 per cent chance of progressing. Bunnell found that in 68 per cent of his patients who had a Risser sign of zero the curve progressed 10 degrees or more.

The question of whether it is possible to use these factors to predict which curve will progress is most intriguing. However, we could not make accurate predictions using single or multiple factors or equations due to the high percentage of false-positive results. Using the factors that had the highest correlation with progression, a graph was con-

structured using the formula:

$$\text{progression factor} = \frac{\text{Cobb angle} - 3 \times \text{Risser sign}}{\text{chronological age}}$$

for curves between 20 and 29 degrees (Fig. 12). The curve was based on only 268 patients, and the data points for the upper end of the curve were based on few patients, making it far less accurate than the lower end of the curve. Using the nomogram shown in Figures 13-A and 13-B, the incidence of progression in a specific curve can be determined. However, the nomogram does not take into account the location of the curve, the patient's sex, or menarchal status, which are other important factors in decision-making. We must stress that the use of the nomogram is to advise the family as to the chance of progression, not to help to decide whether treatment is indicated or not.

The nomogram can be used in conjunction with Table II in planning continuing care. If there is a high chance of

progression, close observation with radiographs at three or four-month intervals is indicated. If the chance of progression is less, the observation can be at six-month intervals. After a follow-up of twelve to eighteen months, and especially after menarche, the incidence of progression is lower, and thus less frequent evaluations are necessary.

This study has pointed out the factors related to progression of small idiopathic scoliotic curves. These factors and the resulting nomogram may help in the decision-making process, especially when advising the family and in planning continuing care. Further study with an expanded series is necessary to more accurately relate the factors to the pattern of the curve. Striving to identify a prognostic progression factor must continue, with clarification of the natural history of the small idiopathic scoliotic curve.

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