Threshold values for supine and standing Cobb angles and rib hump measurements: prognostic factors for scoliosis

Abstract  Seven parameters recorded at the first clinical examination of 326 growing scoliotic patients were correlated with the speed of progression of the scoliotic curve during a natural history survey period. The parameters were: age; bone age (according to Greulich and Pyle); pubertal and Risser stage; curve shape; rib hump, measured in forward bending in a sitting patient and supine and standing radiographic Cobb angles of the scoliotic curve. The speed of progression of the scoliotic curve was expressed as the annual increase in Cobb angle. It was quantified graphically after plotting the measurements taken from all the radiographic examinations made during the survey. The survey period ranged from 6 months to several years, depending on the rate of progression. It was 6 months only if the scoliotic curve demonstrated worsening of more than 3° at two successive examinations performed at least 3 months apart. The authors aimed to identify the minimum values of curve angle and rib hump, identified at first examination in 95–100% of patients whose parameters at follow-up were above these values (supine angle: 17°; standing angle: 24°; rib hump: 11 mm), therefore demonstrating curve worsening. Then, they analysed how the other parameters such as age, bone age, state of maturation and curve shape influenced these threshold values of rib hump and supine and standing angles. The authors present the threshold values for the whole sample according to the sexual state of maturation and also for each curve shape. They demonstrate that a combination of states of maturation, several measures of the scoliotic curve and curve shape provides the best basis for individual prognosis.

Key words  Scoliosis · Curve progression · Prognostic · Threshold · Maturation

Introduction

Since the first publications by Collis and Ponseti and by Duriez [3, 5], many works have emphasized the fact that scoliotic curves can continue to increase during maturity. However, good treatment during growth only can aid in stopping the increase of the deformity. Consequently the tendency is to start treatment for scoliosis at a smaller and smaller angle. These treatments are easier but also longer than those undertaken at a later stage, and they can be only warranted if the scoliotic curve is increasing. Since only 2 out of every 1,000 patients with a minor degree of curvature will have a progressive scoliosis, the challenge is to identify these subjects [2, 14, 15, 17–19]. Hence, prognostic factors for the development of scoliosis must be found. Any such parameter, a qualitative one or a threshold of a quantitative one, must be present at the first
examination for the vast majority (95-100%) of worsening scolioses and must be absent from all the stable scolioses. A combination of several parameters can produce increased reliability with lower thresholds for each parameter.

In a long-term follow up, Lonstein [13] identified a combination of prognostic factors for minor scoliosis – Cobb angle corrected for chronological age and Risser stages – from which the risk of progression could be calculated. The smallest Cobb angle involving a 95% risk of progression was 20° for children below 9 years old. Risser stage is a very late informant parameter during growth of scoliotic patients; Risser stage 0 affects scoliotic patients from 1 to 14 years. Consequently, using Risser stage as a maturation indicator can lead to loss of information. For this reason we also use the early informant parameters of bone age and sexual state of maturation [6, 7, 16].

Research of prognostic factors requires longitudinal studies of the history of each scoliosis, as this is the only means of demonstrating an increase in the deformity. Retrospective studies generally suffer from incomplete data on the parameters measured at first examination or from lack of quantification of the worsening of the deformity. Such studies have established the relationship of both Cobb angle and age with subsequent worsening of the curve [4]. In 1989, on a polycentric and retrospective investigation, we demonstrated the relationship between several clinical and radiological parameters recorded during the first examination of a patient with worsening scoliosis [11, 12], but we were not able to find a threshold of these parameters that would reliably predict worsening. Prospective studies must be of limited duration because of the ethical requirement for treatment, consequently they run a risk of wrong assessment of worsening.

We used a semi-longitudinal approach to study the relationship between the parameters measured during the first examination and development of the scoliotic curve, measured as the annual rate of progression of Cobb angle in 262 growing scoliotic patients selected on account of having a supine Cobb angle and rib hump measurement below 30° and 30 mm, respectively, at first examination. The incidence of scoliotic progression was 95% in those patients for whom the supine Cobb angle was greater than 17°, or the rib hump was above 11 mm at first examination. These threshold values can therefore be used for individual prognoses [8].

The present study employs the same approach. Its purpose is to determine a similar threshold for the standing Cobb angle and to determine how the parameters of curve shape, age, bone age and state of maturation influence these thresholds.

### Materials and methods

Seven parameters were recorded at the first examination of 326 growing idiopathic scoliotic subjects and were correlated with the rate of progression of the scoliotic curve established during a natural history survey period.

#### Initial parameters

- **Supine and standing angle.** This was measured according to the Cobb method.
- **Rib hump.** This was measured with a spirit level with the subject bending forward in a sitting position with the pelvis supported by an assistant.
- **State of maturation.** The subjects were assigned to one of six states:
  - State I: no external sexual sign of puberty
  - State II: just the first external sexual signs of puberty
  - State III: from the first external sexual signs of puberty to menarche
  - State IV: menarche to Risser test of iliac epiphysis French state 1 (first appearance of iliac epiphysis ossification)
  - State V: positive Risser test from French state 1 to 3 (complete progression of iliac epiphysis ossification)
  - State VI: Risser test from French state 4 to 5 (from outset to completion of iliac epiphysis ossification fusion with the iliac crest)

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**Fig. 1A, B** Graphical estimation of the evolution rate of two scoliosis curves (○ thoracic Cobb angle, ◦ lumbar Cobb angle). A A short natural history follow-up, on account of fast worsening. B A longer natural history follow-up, on account of start of puberty and low rate of progression.