The tall girl

Prediction of mature height and management

MICHEL L. COLLE*, HENRY ALPERIN, AND ROBERT B. GREENBLATT

From the Department of Endocrinology, Medical College of Georgia, Augusta, Georgia, USA

SUMMARY The arrest of excessive tallness in girls with hormonal therapy has been reported to be useful, but lack of accuracy in the prediction of ultimate stature based on the tables of Bayley and Pinneau (1952) has allowed only a rough evaluation of its benefits. A series of 40 tall girls were treated with oestrogens and mature stature was evaluated by the method of Tanner *et al.* (1975). Results were compared with those obtained in a previous study made in 1966 where Bayley and Pinneau tables were used.

Hormonal treatment to arrest excessive tallness in girls has been tried in the past (Freed, 1958; Goldzieher, 1956). Most of the studies have reported reduction in the estimated linear growth with oestrogen therapy, but the chief pitfall has been lack of accuracy in the prediction of mature stature as evaluated by the tables of Bayley and Pinneau (1952). Recently, Tanner *et al.* (1975) published equations and tables for prediction of adult height from height, bone age, and occurrence of menarche with allowance for midparent height. We applied this method to a series of 40 tall girls in order to confirm the action of oestrogens, and to compare results with those of a previous study in which predicted ultimate stature was evaluated by the Bayley and Pinneau tables (Greenblatt *et al.*, 1966).

Materials and methods

The study is based on a series of 40 patients with good socioeconomic status, seen in private practice by one of us (R.B.G.), in whom appropriate tests had ruled out endocrinopathy. All patients' heights were >97th centile, age ranged from 10 to 15 years (Fig.). A few untreated patients were available for comparative study and a number had a sister who, without treatment, reached a significantly higher stature.

Stature was measured every 6 months by the same observer until stable over a period of one year. x-rays of left hand and wrist were taken every 6

months and interpreted by one of us (H.A.), using the 'TW2' method of Tanner *et al.* (1962). Each of the designated 13 bones of the hand and wrist were interpreted separately for the stage of growth, which was given a rating based on comparisons with standards. The rating score of each of the bones was added to give a total maturity score, and bone age was determined from this score according to tables provided. Stature of both parents and sibs was recorded either by direct measurement when possible or by information. According to the method of Tanner *et al.* (1962) predicted ultimate stature is obtained by adding present height affected by a coefficient *a*, chronological age affected by a coefficient *b*, skeletal age affected by a coefficient *c*, and *d* a constant. Coefficients *a*, *b*, *c*, and *d* are found in tables provided. Allowance for midparent height is made by adding to the estimate one-third of the amount that the midparent height (one-half of the sum of father and mother heights) deviates from the mean midparent height (168 cm).

Fig. Distribution of 40 patients according to age at onset of therapy and menarche.

*Present address: Service de Pédiatrie et Génétique Médicale, Hôpital des Enfants, 168, Cours de l'Argonne, 33-Bordeaux, France.

Received 3 May 1976

Table 1 Evaluation of oestrogen therapy in 40 patients

Group	Bone age (mean $\pm$ SE) (years)	Initial height (mean $\pm$ SE) (cm)	Midparent height (mean $\pm$ SE) (cm)	Projected height (mean $\pm$ SE) (cm)	Actual final height (mean $\pm$ SE) (cm)	Net growth inhibition (mean $\pm$ SE) (cm)
Group I <12.5 premenarchial	13.3 $\pm$ 0.16	164.0 $\pm$ 0.62	180.1 $\pm$ 1.11	177.4 $\pm$ 1.00	168.2 $\pm$ 0.82	5.2 $\pm$ 0.74
Group II <12.5 postmenarchial	13.8 $\pm$ 0.57	172.6 $\pm$ 2.64	178.5 $\pm$ 1.21	181.6 $\pm$ 2.47	176.5 $\pm$ 2.94	5.5 $\pm$ 1.72
Group III $\geq$ 12.5 premenarchial	13.2 $\pm$ 0.14	167.7 $\pm$ 1.83	179.5 $\pm$ 1.53	177.0 $\pm$ 1.75	173.0 $\pm$ 1.89	4.0 $\pm$ 0.76
Group IV $\geq$ 12.5 postmenarchial	14.4 $\pm$ 0.34	171.2 $\pm$ 1.67	178.0 $\pm$ 1.22	177.4 $\pm$ 1.31	174.5 $\pm$ 1.26	2.9 $\pm$ 0.35

Treatment. Oestrogen therapy was administered uninterruptedly with 25 mg pellets of oestradiol (5–7 in number) implanted every 6 months until epiphyses were closed or almost closed. An oral progestational agent, such as norethindrone acetate (5 mg) or medroxyprogesterone acetate (10 mg), was given for 5 to 7 days each month to induce cyclic withdrawal periods.

Results

We divided the patients into four groups. Group I, 21 premenarchial patients 10–12 years old at onset of therapy; group II, 3 postmenarchial girls in the same age range; group III, 8 premenarchial patients 12.5 to 15 years of age; and group IV, 8 postmenarchial patients in the same age range as group III. Data for skeletal maturation were also divided into three groups: 12.1–13 years, 13.1–14 years, and 14.1–16 years of bone age. (The following results are all expressed in terms of mean value $\pm$ SE.) In group I (Table 1), bone age was 13.3 $\pm$ 0.16 years, range 12.7–15.7 years; and height at onset of treatment was 164.0 $\pm$ 0.62 cm, range 158.7–168.2 cm. Midparent height was 180.1 $\pm$ 1.11 cm. Growth under treatment averaged 4.2 cm, the final height being 168.2 $\pm$ 0.82 cm. After completion of treatment, net growth inhibition defined as the difference between predicted height and actual final height, was 5.2 $\pm$ 0.74 cm. Only 3 patients were in group II and results are not significant. In these 3 patients, net growth inhibition was respectively 2.8, 5.0, and 8.7 cm. In group III bone age, midparent height, and projected height were comparable to those in group I. Height at onset of therapy was significantly higher (167.7 $\pm$ 1.83 cm) than in group I, average growth under treatment was 5.3 cm and net growth inhibition was 4.0 $\pm$ 0.76 cm. In group IV bone age was significantly higher (14.4 $\pm$ 0.34) than in the other groups, and average growth during treatment was 3.3 cm. Net growth inhibition was 2.9 $\pm$ 0.35 cm. When results were compared to skeletal age, net growth inhibition appeared to be 5.98 $\pm$ 1.19 cm

in the group of 12.1–13 years, 5.18 $\pm$ 0.56 in the group 13.1–14 years, and 2.33 $\pm$ 0.60 in the group 14.1–16 years of skeletal age.

In an attempt to find a relationship between the results of the treatment and the various factors involved in the prediction of the mature stature, we evaluated in each group of patients a 'coefficient of growth' as the ratio between growth under treatment (final height—height at onset of treatment) and potential growth (predicted height—height at onset of treatment) (Table 2). Coefficient of growth was

Table 2 Evaluation of the coefficient of growth in 4 different groups of patients

Group	Potential growth (predicted height —initial height)	Actual growth (final height —initial height)	Coefficient of growth (actual growth/potential growth)
Group I 10–12 yr premenarchial	12.81 $\pm$ 0.87	7.14 $\pm$ 0.41	0.60 $\pm$ 0.06
Group II 10–12 yr postmenarchial	8.90 $\pm$ 1.94	3.83 $\pm$ 0.72	0.46 $\pm$ 0.05
Group III 12.5–15 yr premenarchial	9.26 $\pm$ 0.67	5.30 $\pm$ 0.31	0.60 $\pm$ 0.05
Group IV 12.5–15 yr postmenarchial	6.20 $\pm$ 1.06	3.30 $\pm$ 1.07	0.46 $\pm$ 0.08

found to be significantly different in pre- and postmenarchial girls, being 0.60 in premenarchial and 0.46 in postmenarchial patients. A coefficient of growth inhibition was deducted from the coefficient of growth as the amount that coefficient of growth differs from 1 and thus is found to be 0.40 in premenarchial and 0.54 in postmenarchial patients.

Discussion

Several reports have shown the efficacy of oestrogen therapy in tall girls and net growth inhibition has averaged 4 cm in most of the studies. Table 3 compares our results obtained in a series of 24 patients in which prediction of mature stature was done using

Table 3 Effect of oestrogen therapy on growth inhibition when mature stature is estimated by 2 different methods (mean $\pm$ SE)

	Growth inhibition (cm)	
	Bayley and Pinneau tables (1966) (24 patients)	Method of Tanner et al. (1975) (40 patients)
All patients	1.06 $\pm$ 1.02	4.52 $\pm$ 0.46
11 yr	9.6 $\pm$ 0.5	5.37 $\pm$ 1.08
12 yr	4.06 $\pm$ 1.27	4.87 $\pm$ 0.69
13-15 yr	0.76	3.20 $\pm$ 0.43

the tables of Bayley and Pinneau (Greenblatt *et al.*, 1966) with the present series of 40 patients where results are evaluated using the method of Tanner *et al.* (1975). No significant difference in average net growth inhibition was found, but the Bayley and Pinneau tables show a marked difference in results between younger and older patients whereas the difference is only moderate with the method of Tanner *et al.* We are aware of only one other study where predicted stature was calculated with the method of Tanner *et al.* Zachmann *et al.* (1976) found an average growth inhibition of 4.6 ± 2.4 cm for their 40 patients treated, ranging from 5.8 cm for the group 12.1-13 years of bone age to 4.5 cm for the group 14.1-15 years. These results, comparable to ours, suggest that if benefit of oestrogen therapy is greater in young girls with immature epiphyses, a fair result may be obtained in older girls as long as epiphyses remain open.

Many authors feel that the prediction of ultimate stature on the basis of Bayley and Pinneau tables is not wholly valid. The method of Tanner *et al.* (1975) based on multiple regression equations for predicting the adult height of girls from height and bone age seems to be of great accuracy and different tables are provided for pre- and postmenarchial girls. Their 'TW2' method allows greater flexibility and accuracy in the over-all growth maturity assessment by not requiring the observer to calculate the 'bone age' on one standard x-ray, as in the method of Greulich and Pyle (1959). Each bone is judged separately as to its true maturity and the final determination is a more accurate reflection of the true skeletal maturation. Inclusion of midparent height further improves the predictions, but Tanner *et al.* point out that further studies on larger groups of parents should improve the adjustment. Furthermore, they emphasize the need for the investigator himself to measure both parents' height because of the usual inaccuracy of information derived from hearsay. In general, errors of predic-

tion with the method of Tanner *et al.* are slightly smaller than those arising from Bayley and Pinneau tables in premenarchial girls, but in practice, as pointed out by Marshall (1975), neither method is ideal when applied to tall girls.

The determination in this series of 40 patients of a coefficient of growth inhibition allows a rough deduction of the expected growth inhibition under oestrogen therapy from the evaluation of the potential of growth affected by the coefficient 0.40 in premenarchial and 0.54 in postmenarchial girls.

This study confirms the efficacy of oestrogen therapy in reducing mature stature of tall girls. It supports the fact that the method of Tanner *et al.* applied to prediction of ultimate height is useful in the management of these patients. However, since no extensive data concerning the effect of prolonged oestrogen therapy are yet available, the decision to treat a tall girl requires the most accurate possible appreciation of the benefits one might expect.

References

- Bayley, N., and Pinneau, S. R. (1952). Tables for predicting adult height from skeletal age. *Journal of Pediatrics*, **40**, 423-441.
- Freed, S. C. (1958). Suppression of growth in excessively tall girls. *Journal of the American Medical Association*, **166**, 1322-1323.
- Goldzieher, M. A. (1956). Treatment of excessive growth in the adolescent female. *Journal of Clinical Endocrinology and Metabolism*, **16**, 249-252.
- Greenblatt, R. B., McDonough, P. G., and Mahesh, V. B. (1966). Estrogen therapy in inhibition of growth. *Journal of Clinical Endocrinology and Metabolism*, **26**, 1185-1191.
- Greulich, W. W., and Pyle, S. I. (1959). *Radiographic Atlas of Skeletal Development of the Hand and Wrist*, 2nd ed. Stanford University Press, Stanford, California.
- Marshall, W. A. (1975). What can we do about tall girls? *Archives of Disease in Childhood*, **50**, 671-673.
- Tanner, J. M., Whitehouse, R. H., and Healy, M. J. R. (1962). *A New System for Estimating Skeletal Maturity from the Hand and Wrist with Standards Derived from a Study of 2600 Healthy British Children*. Parts I and II. Centre International de l'Enfance, Paris.
- Tanner, J. M., Whitehouse, R. H., Marshall, W. A., and Carter, B. S. (1975). Prediction of adult height from height, bone age, and occurrence of menarche, at ages 4 to 16 with allowance for midparent height. *Archives of Disease in Childhood*, **50**, 14-26.
- Zachmann, M., Murset, G., Fernandez, A., Pluznik, S., and Prader, A. (1976). Excessively tall stature in girls. Further experience with sex hormone treatment in high doses. *European Society for Paediatric Endocrinology, 14th Annual Meeting, 1975* (in press).

Correspondence to Dr. R. Greenblatt, Department of Endocrinology, Medical College of Georgia, Augusta, Georgia 30902, U.S.A.