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A STUDY OF HEIGHT, WEIGHT AND MENARCHE IN GIRLS WITH IDIOPATHIC STRUCTURAL SCOLIOSIS

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It has been established that the deformity in structural scoliosis tends to increase more during periods of rapid growth (James 1967). This fact appears to be unrelated to the etiology of scoliosis which is unknown in about 90 per cent of the cases (Cobb 1948). In addition it is known that deformity less than 60° usually does not increase after the cessation of growth. Collis & Ponseti (1969), however, have shown that more severe thoracic and thoracolumbar scolioses tend to increase even in adult age, mostly due to secondary changes in the intervertebral discs. It has previously been demonstrated (Willner 1974) that children with scoliosis are significantly taller than children without scoliosis, even if the shortening of the trunk caused by the deformity is disregarded, and this was found in boys as well as in girls. These observations were made on a heterogenous material of 1,616 children with structural or non-structural scoliosis of varying degree and type. The majority of the cases were mild. About 25 per cent of the cases were structural and the remainder were cases of so-called functional scoliosis where the deformity could be completely reduced. There were too few cases of severe scoliosis to permit comparison of growth patterns between mild and severe types.

The object of the present study was to investigate height, weight and menarcheal age in a series of cases with definite idiopathic structural scoliosis and to compare the data between severe and mild cases and between girls with and without scoliosis.

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MATERIAL AND METHODS

Altogether 311 girls who had been treated in the Department of Orthopaedic Surgery of the Sahlgrenska Hospital in Gothenburg from 1963 to 1971 were included in the study. The cases were drawn from the population of southern and western Sweden. Only cases with unknown etiology and pathogenesis were included—idiopathic structural scoliosis.

Severity of Deformity

The cases were subdivided in three sets with regard to the severity of deformity: $< 20^\circ$, 20° – 40° and $> 40^\circ$ according to Cobb (1948) (Table 1).

Table 1. *Severity of scoliosis.*

	$< 20^\circ$	20° – 40°	$> 40^\circ$
No. of cases	114	65	132

Girls with a deformity exceeding 20° had been treated with the Milwaukee brace (Blount et al. 1958); girls with a deformity of 50° or more had in most instances been operated on with internal fixation and spinal fusion according to Harrington (1962). The surgical procedure was modified by Nachemson with operation in two seances. Both the latter groups had been admitted to hospital. The remaining 114 girls had only been seen ambulatory and had not been treated.

Age at Diagnosis

The age at diagnosis was defined as the age at which the deformity was first noted, usually before the child was seen in the Orthopaedic Department. The age-distribution at the time of diagnosis (girls admitted) is demonstrated in Table 2. The cases were also subdivided into two groups according to the age at the time of diagnosis: before the age of 10—*early diagnosis* (32 girls), after the age of 10—*late diagnosis* (165 girls). The age limit was chosen to separate the cases diagnosed before and after the prepuberal growth. The older of the two subsets may be referred to as suffering from adolescent idiopathic scoliosis (Goldstein et al. Scoliosis Research Society 1969).

Table 2. *Age at diagnosis.*

	< 4	4	5	6	7	8	9	10	11	12	13	14	15
No. of cases	2	1	1	5	6	10	7	13	28	39	41	30	14

Height

The height was measured in the standing position. The measured value was also corrected for the height reduction caused by the scoliosis according to the method of Bjure et al. (1968). The degree of scoliosis estimated according to Cobb (1948) was used as a base value. All the measurements were performed by the same investigator.

Weight

The body weight was recorded at the time of admission in 196 girls who had been admitted to hospital.

Menarche

The menarcheal age was recorded in girls admitted to hospital. Of these the follow-up time with regard to this variable (age < 15) was incomplete in 57 cases. Among the remainder data were missing in three, leaving 137.

The height and weight measures were recorded at the time of first examination. In addition the height was studied longitudinally in the girls admitted.

Controls

The heights were compared to the data of a series of girls without scoliosis described by Willner (1974). This latter series has been demonstrated to agree well with several contemporary height studies of children in Scandinavia and the data were collected during approximately the same period as those of the present study.

Standard statistical methods were applied to the data and differences with a probability level of 95 per cent or better are referred to as significant.

RESULTS

Height

The height, corrected for the deformity, was significantly greater in girls with scoliosis than in the controls. Also, in some age groups the uncorrected heights were increased above normal and on the whole, the growth curve of girls with scoliosis, even disregarding the shortening caused by the deformity, differed from that of the controls (Figure 1, and Table 3). However, the uncorrected growth curve and the curve representing normal growth appear to merge in adult age.

The three ranks of severity, < 20°, 20°–40°, > 40°, all differed from the controls in their corrected height values but did not deviate from each other (Figure 2, and Table 4).

Girls with an early diagnosis of their deformity did not differ in height from the controls in most of the age groups but differed significantly from girls with a late diagnosis (Figure 3, Table 5).

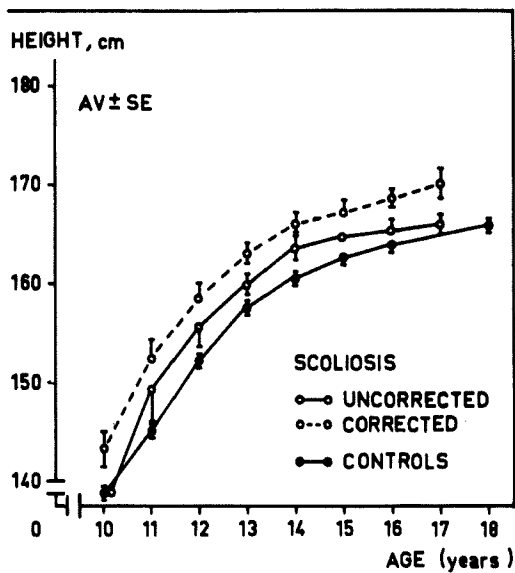


Figure 1. Comparison of height of girls with and without idiopathic scoliosis.

Figure 2. Comparison of height between ranks of severity of idiopathic scoliosis.

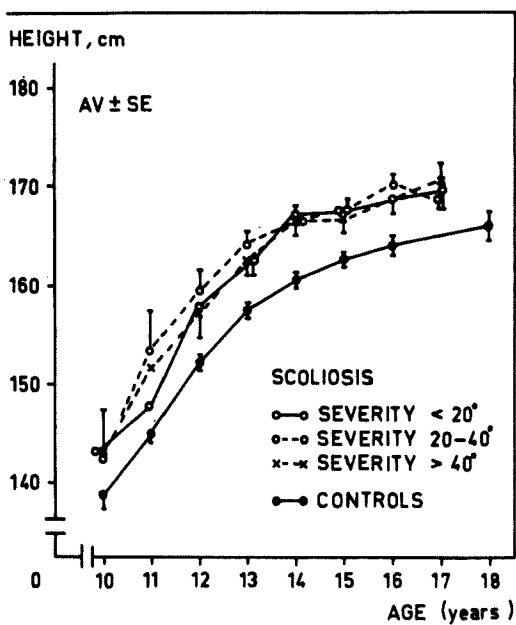


Table 3. Comparison of height of girls with and without idiopathic scoliosis.

Age	Height (cm)								
	Scoliosis						Controls		
	Corrected			Uncorrected					
	Mean	n	SD	Mean	n	SD	Mean	n	SD
10 (9.5-10.5)	143.0	7	4.6	139.0	7	9.9	138.9	110	5.5
11 -	152.3	9	5.8	149.4	9	9.3	145.0	101	5.9
12 -	158.3	24	7.7	155.6	24	8.1	152.3	102	5.8
13 -	162.9	35	5.8	159.9	35	6.3	157.5	103	6.1
14 -	166.3	40	6.7	163.9	40	8.9	160.6	100	5.0
15 -	167.6	35	7.0	164.6	35	8.0	162.6	55	5.0
16 -	168.6	31	4.4	165.4	31	4.7	163.7	98	4.9
17 -	170.1	16	6.4	165.9	16	5.7			
18 -							165.8	98	6.0
19 -							165.7	57	6.1

Table 4. Comparison of height between ranks of severity of scoliosis.

Age	Height (cm)								
	Scoliosis								
	< 20°			20°-40°			> 40°		
	Mean	n	SD	Mean	n	SD	Mean	n	SD
10 (9.5-10.5)	143.9	11	7.7	142.5	3	7.8	143.3	4	1.5
11 -	147.6	16	9.2	153.6	3	7.1	151.7	6	5.6
12 -	157.5	14	8.4	159.5	11	6.0	157.3	13	9.0
13 -	162.5	35	7.4	164.2	13	4.3	162.2	22	6.5
14 -	167.2	45	5.7	166.3	8	5.5	166.2	32	7.0
15 -	167.4	45	5.9	167.6	12	7.0	166.7	23	7.6
16 -	168.4	31	6.5	168.4	13	4.0	168.5	18	5.4
17 -	169.6	12	6.6	168.6	2	2.7	170.6	14	6.5

The growth rate calculated as annual growth and based on longitudinal data from scoliosis (corrected height) and control girls indicate that although the girls with scoliosis were taller the growth rate after the age of 10 was less (Figure 4, and Table 6).

Weight

Data on weight for controls were not corrected for the purpose of the present study, and therefore the weights of the children with scoliosis

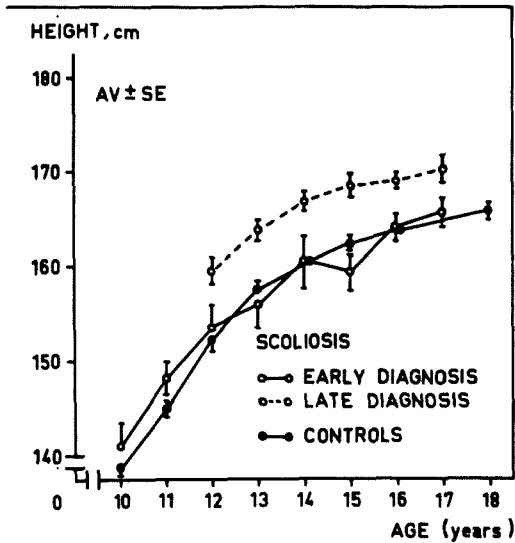


Figure 3. Comparison of height in idiopathic scoliosis with early and late diagnosis.

were compared to data produced by Karlberg et al. (1972) (Table 7, and Figure 5). In spite of the fact that the corrected height of the children with scoliosis exceeded that of the controls their weight was the same up to the age of 12 and later even less. When their weight was related to a corrected height the difference became still more pronounced. When corrected for height the difference in weight became even more obvious (Figure 6) in that children with scoliosis ceased to increase their weight much earlier than the control children. The difference was significant.

Menarche

The age at menarche was $13.1 \pm 1.2^*$. In Table 8 this value may be compared to available data on menarcheal age.

The menarcheal age in girls with scoliosis cannot be demonstrated to deviate from that of the population at risk.

However, in girls with a late onset of idiopathic scoliosis there was a significant positive relationship between the age at menarche and the age at the time of diagnosis (Figure 7). In girls with early onset too few were followed up to the age of menarche to permit calculations.

* Average $\pm$ standard deviation.

Table 5. Comparison of height in scoliosis (corrected) with early and late diagnosis.

Age	Height (cm)					
	Diagnosis					
	Early			Late		
	Mean	n	SD	Mean	n	SD
10 (9.5-10.5)	141.2	5	4.8			
11 -	148.3	10	6.0			
12 -	153.7	11	8.3	159.6	19	6.3
13 -	156.2	13	8.2	163.7	30	5.4
14 -	160.6	7	7.3	166.6	38	6.7
15 -	159.5	8	5.3	168.6	32	6.4
16 -	164.4	8	3.1	169.0	30	4.5
17 -	165.8	5	3.3	170.1	16	6.4

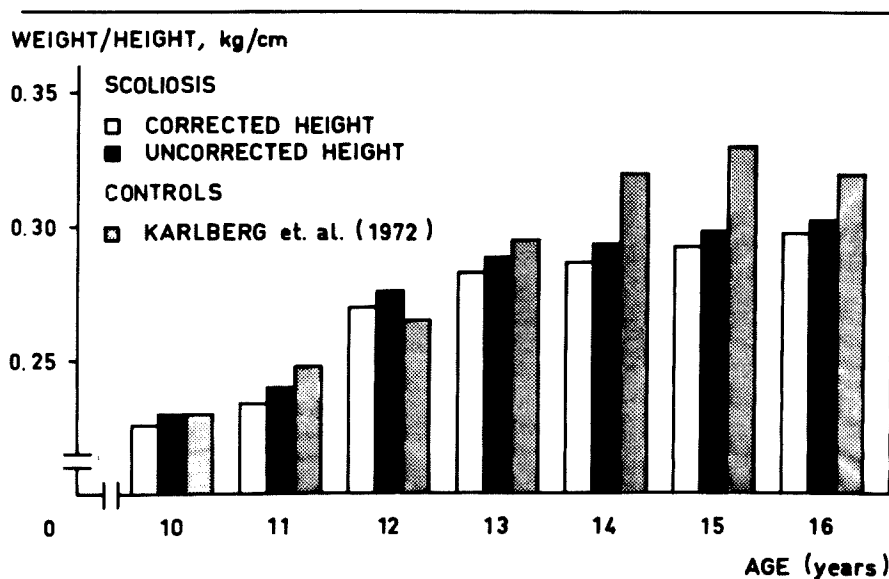


Figure 4. Comparison of height gain per year of girls with and without scoliosis. After the age of 15 no controls were available.

DISCUSSION

Figure 4 shows that the growth rate was greater in the control cases than in the cases with scoliosis. Nevertheless Figure 1 shows the scoliotic girls in all age groups to be taller than the controls. This can

Table 6. Comparison of growth rate of girls with idiopathic structural scoliosis and controls.

Age (years)	Growth rate (cm/year)							
	Idiopathic scoliosis				Controls			
	Mean	n	SD	SE	Mean	n	SD	SE
10	5.7	6	3.2	1.3	6.3	100	2.1	0.2
11	5.6	15	2.6	0.7	7.0	100	2.1	0.2
12	4.6	24	1.7	0.3	5.5	100	2.1	0.2
13	2.6	44	1.6	0.2	3.2	95	2.0	0.2
14	1.7	57	1.7	0.2	1.6	70	1.4	0.2
15	0.8	61	1.0	0.1	1.1	47	1.1	0.2
16	0.5	51	0.8	0.1				
17	0.1	39	0.3	0.1				
18	0	6	0	0				

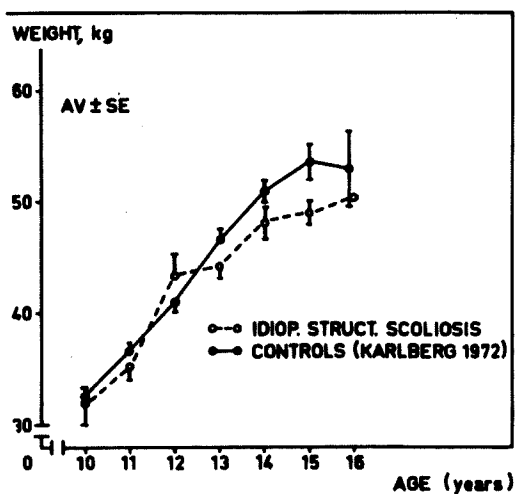


Figure 5. Comparison of weight of girls with and without idiopathic scoliosis.

be explained by the previously demonstrated increase in growth rate before the age of 10 in children with scoliosis (Willner 1974).

The discovery that girls with scoliosis in spite of their deformity are not shorter than girls without scoliosis may be somewhat surprising considering the clinical experience that scoliosis in severe cases may render an individual very short. However, if only the most extreme

Table 7. Comparison of weight (kg) of girls with idiopathic structural scoliosis and non-scoliotic controls (Karlberg 1972).

Age (years)	Weight (kg)					
	Scoliosis			Controls		
	Mean	n	SD	Mean	n	SD
10 (9.5-10.5)	32.0	7	6.3	32.6	76	6.2
11 -	35.3	9	4.5	36.7	76	6.9
12 -	43.7	24	9.8	41.0	77	8.4
13 -	44.3	35	6.0	46.7	73	8.3
14 -	48.4	40	9.3	51.0	75	8.3
15 -	49.4	35	6.7	53.8	16	7.4
16 -	50.4	31	3.8	53.0	3	6.4
17 -	49.5	15	5.7			

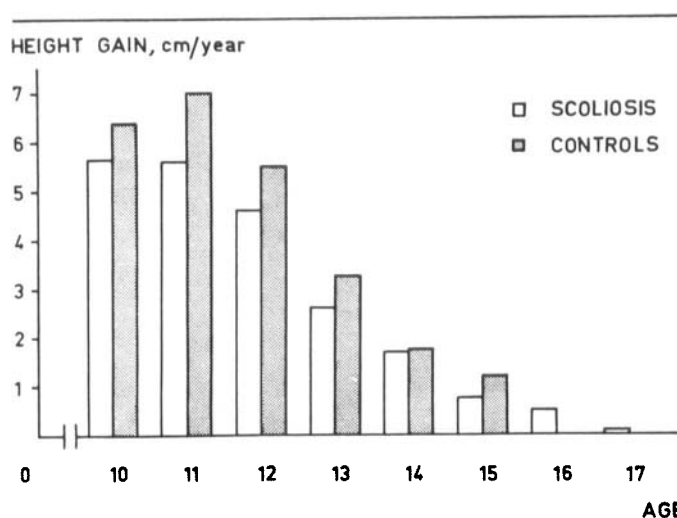


Figure 6. Comparison of weight/height (kg/cm) of girls with and without scoliosis.

subset in the present study, children with a deformity of more than 40° , were studied, their average uncorrected height still was not less than that of the controls but rather the reverse (Figure 8).

The growth rate calculated on the longitudinal data, however, may to some extent be influenced by the fact that many of these girls had been treated with the Milwaukee brace.

Surgery does not influence the shape of the growth curves presented

Table 8. Data on menarcheal age (Marshall & Tanner 1968).

		Age at menarche
Denmark	1963	13.1 ± 0.12
Poland (Warsaw)	1965	13.0 ± 0.04
Australia (Melbourne)	1966	13.2 ± 0.9
USSR (Moscow)	1965	13.0
Italy (Florence)	1960	12.5 ± 0.11

in Figures 1–3 which are based on measurements taken before any operative treatment had been applied.

The longitudinal height study in girls with an early onset was, however, continued beyond the surgical treatment and in the comparison to girls with late onset, results may to some extent be influenced by disturbances resulting from surgery.

The basic etiology of idiopathic structural scoliosis is unknown but a contributing factor appears in many of the cases to be a deviation from the normal growth pattern including an early growth spurt. If the basic requirements were sufficiently penetrating, an additional requirement such as an abnormal growth pattern should not be needed and the body height should not deviate from that of the normal population.

There seems to be a difference with regard to the presence of this

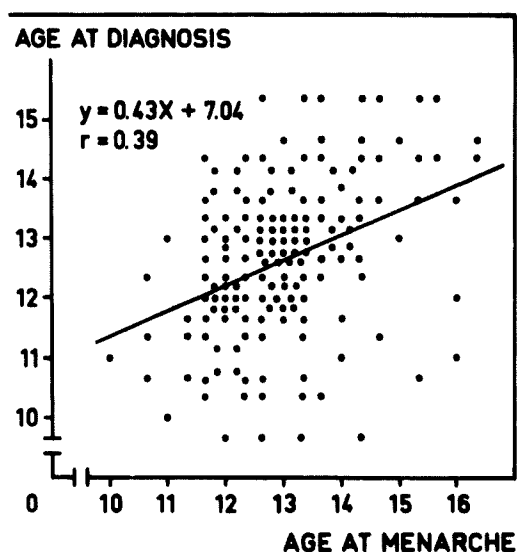
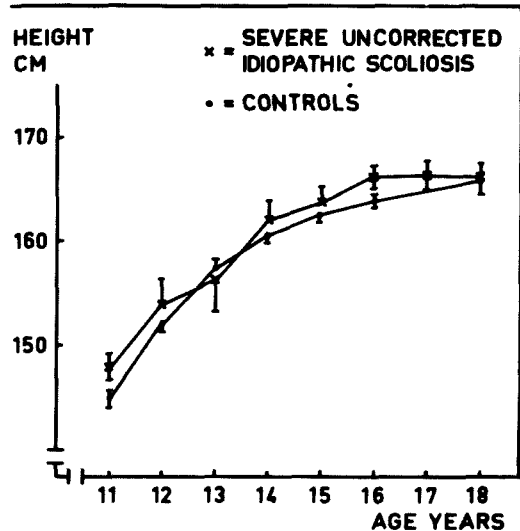


Figure 7. The relationship of age at diagnosis and menarche in girls with scoliosis. Girls with diagnosis before the age of 10 are excluded.

Figure 8. Comparison of height between girls with uncorrected severe ($> 40^\circ$) idiopathic scoliosis and girls without scoliosis.



abnormal growth pattern between adolescent idiopathic scoliosis and scoliosis with diagnosis before the age of 10.

In the literature James (1967) among others has shown some differences between adolescent and infantile scoliosis. One of these is the sex distribution. Sixty per cent of the total occurrence of infantile scoliosis is in boys while 90 per cent of the total occurrence of adolescent scoliosis is in girls. In adolescent scoliosis the proximal curve is usually convex to the right (90 per cent) while in infantile scoliosis the curvature is to the left (88 per cent) (James 1954, 1967). An additional difference between the two types of scoliosis can be found in the differences in mean average height demonstrated in the present study.

Menarche may be used as a sign of maturity. In the present study the age at menarche *per se* did not deviate from that of normal girls. However, within the group of girls with scoliosis a significant positive relationship could be demonstrated to exist between the age at diagnosis of the scoliosis and the age at menarche. Therefore there seems to be a certain relationship between maturation and scoliosis not only with regard to the growth in height.

The data of the present study in combination with the data of a previous study on the growth pattern in scoliosis (Willner 1974) indicate that children with scoliosis are taller than children without this

deformity. As this conclusion is based on two separate independent series of observations which are being compared to four independent series of height studies in normal children it must be postulated that children with scoliosis in Sweden are taller than the average population.

SUMMARY

In a series of girls with idiopathic structural scoliosis the height, weight and age at menarche were studied. It was found that the girls were on the average taller than a control population and that except for the most severe cases their height was greater even if the trunk shortening caused by the deformity was not accounted for. The girls with scoliosis were also somewhat leaner. They did not deviate in age at menarche from normal girls in Sweden but there was a positive relationship between the age at diagnosis of the deformity and the age at menarche. When assessed together with previous data on the subject of height in children with scoliosis in Sweden it must be concluded that children with this deformity have a growth pattern which deviates significantly from that of the normal population.

REFERENCES

- Bjure, J., Grimby, G. & Nachemson, A. (1968) Correction of body height in predicting spirometric values in scoliotic patients. *Scand. J. clin. Lab. Invest.* **21**, 190.
- Blount, W. P., Schmidt, A. C. & Bidwell, R. G. (1958) Making the Milwaukee brace. *J. Bone Jt Surg.* **40-A**, 526.
- Cobb, J. R. (1948) Outline for the study of scoliosis. *Instruct. Course Lectures. Amer. Academy of Orthopaedics*, p. 261.
- Collis, D. K. & Ponseti, I. V. (1969) Long-term follow-up of patients with idiopathic scoliosis not treated surgically. *J. Bone Jt Surg.* **51-A**, 425.
- Duval-Beaupère, G. (1971) Pathogenic relationship between scoliosis and growth. *Scoliosis and growth*. Ed. Zorab, P. A., Churchill Livingstone, Edinburgh and London.
- Goldstein, L., Hall, J., Harrington, P. R., Schmidt, A. C. & Stelling, F. H. (1969) Report of the Terminology Committee 22 Sept. Scoliosis Research Society.
- Harrington, P. R. (1962) Treatment of scoliosis. Correction and internal fixation by spine instrumentation. *J. Bone Jt Surg.* **44-A**, 591.
- James, J. I. P. (1954) Idiopathic scoliosis: the prognosis, diagnosis and operative indications related to curve patterns and the age of onset. *J. Bone Jt Surg.* **41-B**, 36.
- James, J. I. P. (1967) *Scoliosis*. E. & S. Livingstone Ltd., Edinburgh and London.
- Karlberg, P., Engström, I., Lichtenstein, H., Svennberg, I. & Taranger, J. (1972) In preparation.

- Marshall, W. A. & Tanner, J. M. (1968) Growth and physiological development during adolescence. *Ann. Rev. Med.* **19**, 283.
- Willner, S. (1974) Growth in height of children with scoliosis. *Acta orthop. scand.* **45**, 854.

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