ANALYSIS OF THE ANATOMICAL SPINAL CURVES OF SPORT PRACTICING CHILDREN 6 - 12 YEARS OLD

WIELKI, C.
Medicine Faculty U.C.L.
Heverlèe
Belgium

The idea to use electronics in the measurement of the spinal curve was put into practice in 1974 by manufacturing the "Wielki's Electronic Spherosomatograph" permitting at the same time the recording of Spinal curves in the sagittal plane: lordosis and kyphosis and in the frontal plane : scoliosis. This was presented in Marseille (Wielki, 1979).

Previously it has been shown that the dorsal curvature of the normal subject in active standing position could be expressed by the size of the radius of the dorsal curve and the radius of the lumbar curve, therefore the analysis of these results was named the "Radius Method", and was presented at Nagoya (Wielki, 1981).

In further application of the Radius Method a pilot study developed the "model spine". The development allowed for the elaboration of 10 indexes. It was finally called "Improved Radius Method with Intersection Point", and was presented in Halifax and Montana (Wielki et al, 1986, 1988).

Child in free standing position.

Stabilisation of the body at 3 levels (feet-hips-head).

Heels at the same hight either touching or open.

Arms along the body.

Head in "Frankfurt" position.

Recording during controlled breathing from C_7 until L_5= 3cm.

Figure 1: Recording of the Rachi's using "Wielki's Electronic Spherosomatograph".

MATERIALS AND METHOD

Looking at the first recording of the spinal curves we had the intuition that the two parts of the whole spinal curve depended on each other in length as in height. By trying to discover an analysis system it was noticed that a common system could be applied on the dorsal and lumbar curves, if point C was really the point where the dorsal and lumbar curve met.

It was discovered that a straight line starting from the upper point of dorsal curve (A), to the lower point of the lumbar curve (B) intersects the spine at exactly point (C), where the dorsal curve meets the lumbar curve on the condition that A is situated at C7 vertebra and B is situated at L5+8 % of the measured rachi (4 cm for adults, about 3 cm for children).

It must be noted that when the spine is recorded, the subject is in the "standing dynamic free position", the position of the Rachi is not vertical but leans slightly forward on account of the evolution from one curve of the spine before the birth to four during growth. Therefore the top of the dorsal curve D as the top of the lumbar curve E must be measured as a function of their cord: A ->C and C ->B, and not the vertical.

By applying the theory of Pytagore one can express the curves by the size for their radius (Fig. 2).

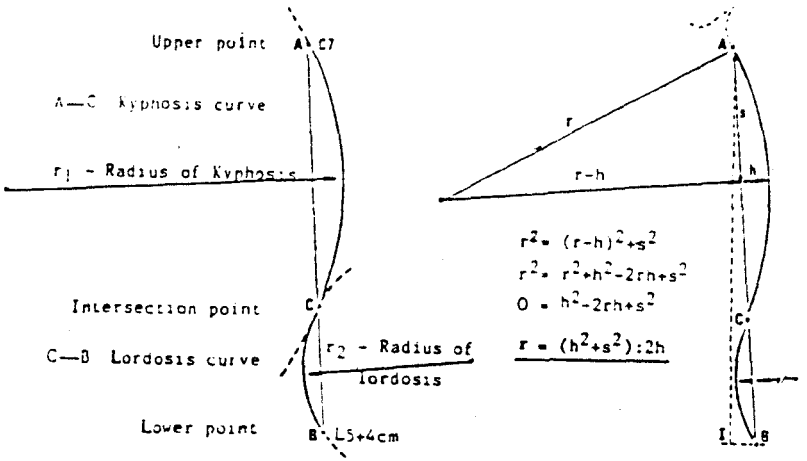

Figure 2: Radius Method with Intersection Point (s = semi-cord of Kyphosis).

Applying the Improved Radius Method with Intersection Point to 476 subjects (286 Males, 190 Females - "Normative Group") it was found that the relation between length of the dorsal curve to that of the lumbar curve and the relation between the heights of the curves were about two to one.

Statistical analysis indicates that more than 80 % of this sample (students) presented the same relation as the whole Normative Group. Therefore, curves with these characteristics were named "Type Normal A".

But for 10% of the subjects the relation between the lengths of the curves was a little more than one to one, while the relation between the heights was a little less than one to one. The anatomical curves with these characteristics were named "Type Lordotic B".

Moreover for about 10% of the subjects the relation between the lengths was about four to one and the relation between the heights six to one. The curves with these characteristics were named "Type Kyphotic C". (Figure 3)

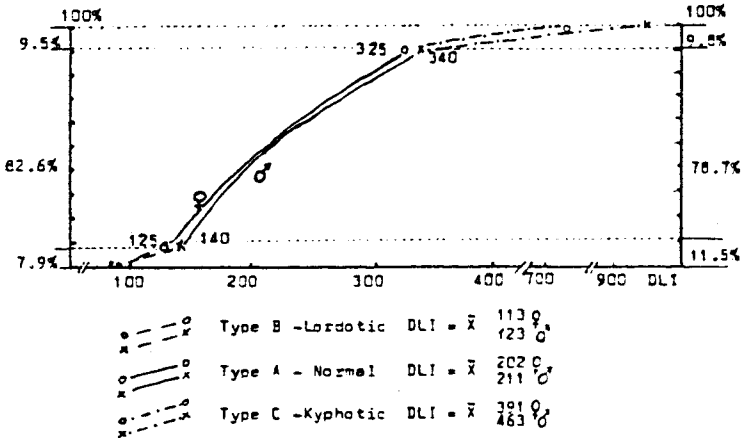

Figure 3: Cumulative Frequence of DLI of "Normative Group" (190 F, 286 M).

This classification has been checked on both sexes, it is a statement of facts and not speculation. It allows one to study the evolution of the rachi taking into consideration 10 Indexes (Figure 4).

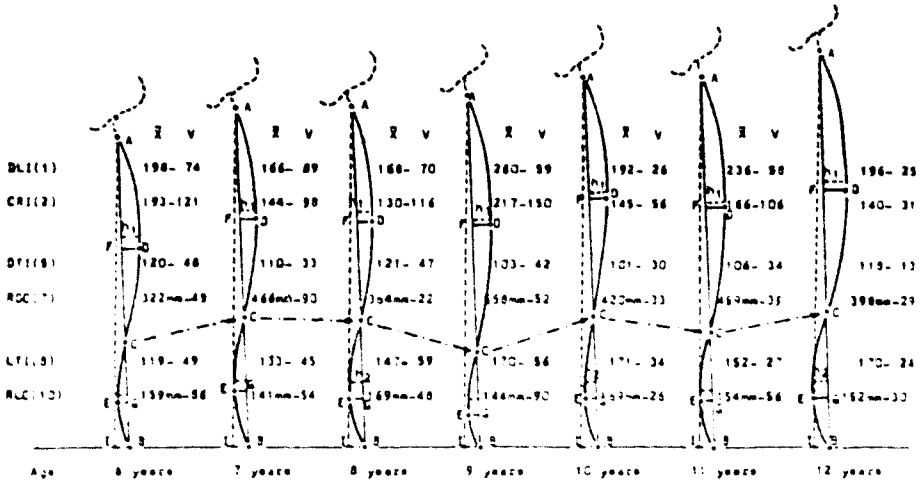

Figure 4: Profiles of Normative Types Anatomical Rachi Curves and their Indexes.(Women : 190, Men : 236)

Four Indexes for the whole curve of the Rachi's

1. Dorso-Lumbar Index : DLI(1) = (AC : CB) x 100,- Relation between length of dorsal and lumbar curve.
2. Curve Relative Index : CRI (2) = (h1 : h2) x 100,- Relation between heights of dorsal and lumbar part
3. Relative Summation Index : RSI (3) = (h1 + h2) : (AC + CB) x 100,- Ratio of sum of the heights to the total length of the rachis.
4. Inclination Index : II (4) = (BI : AI) x 100,- Inclination of the Rachi to the vertical.

Three Indexes for the Dorsal part.

5. Dorsal Top Index : DTI (5) = (AF : FC) x 100,- Position of the Top "D" of the Dorsal part of Rachi's.
6. Dorsal Curve Index : DCI (6) = $(h1_2 : AC)_2$ x 100,- Relation between height and length of the Dorsal part
7. Radius Dorsal Curve: RDC (7) = $(h_1^2 + s_1^2) : 2h_1$,- Size of the Radius of the Dorsal Curve.

Three Indexes for the Lumbar part

8. Lumbar Top Index: LTI(8) = (CG : GB) x 100,- Position of the Top "E" of the Lumbar part of Rachi's.
9. Lumbar Curve Index: LCI(9) = (h2 : CB) x 100,- Relation between height and length of the Lumbar part.
10. Radius Lumbar Curve : RLC(10) = $(h_2^2 + s_2^2) : 2h_2$,- Size of the Radius of the Lumbar Curve.

In this paper, an analysis of the Spinal Curves of children aged 6 to 12 years old will be presented.

RESULTS AND DISCUSSIONS

The data concerning 82 children practicing voluntary out-of-school-sport activities and aged from 6 to 12 years are presented in Figure 5 and the Table.

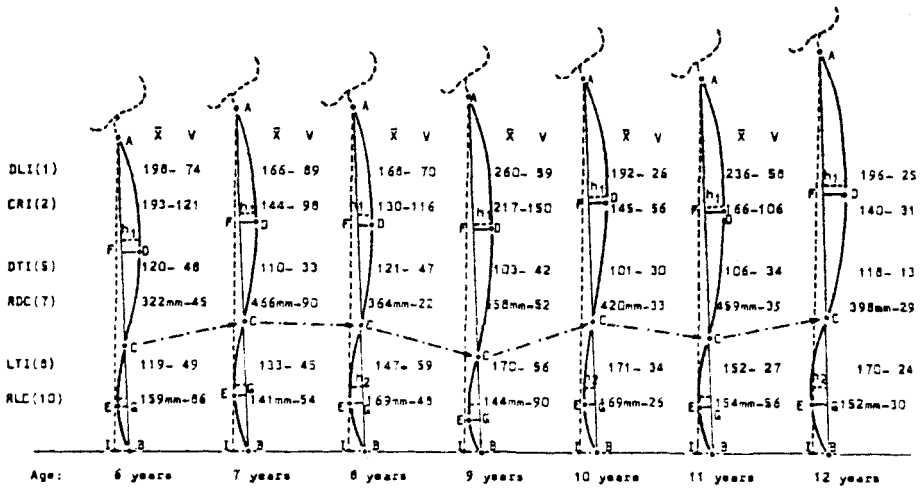

Figure 5: Profiles of anatomical Rachi Curves of children 6 -12 years old and their characteristics by Means ($\bar{X}$) of 6 Indexes.

The children have been divided into yearly age-groups starting from 5 1/2 to 6 1/2, this constitutes the 6 year age-group. All the age-group are formed in the same way. The shapes of the profiles in each age-group are characterized by 6 selected Indexes and the Coefficient of Variation : V = (SDx100) : $\bar{X}$.

Situation of whole curve.

Considering the value of DLI(1) relation of length of dorsal to length of lumbar curve, it was found to be lowest in the 7 years age-group (DLI=166) and the 8 years (168). The highest value was found in the 9 years (260), the next one (236) was in the 11 year. The 6 year with 198, the 10 years with 192, the 12 years with 196 and the 11 years with 236 are closest to the means of the "Normative Group" where DLI = 215.

As far as the value of $\bar{X}$ of CRI(2) is concerned, relation of height of dorsal curve to height of lumbar curve, the lowest value was found in the 8 years age-group (CRI = 130), followed by 12 years (140). It was a little more with 7 years (144) and the 10 years (145). The highest value is in the 9 years (217) and the 6 years (193). These are close to X of "Normative Group" (202).

Regarding the value of the Coefficient of Variation for DLI(1), the differences inside each age-group are important. The lowest value of V is 25 in the 11 years while the highest are in 7 years (89) and 6 years(74).

In the case of CRI(2) the differences on V are enormous : 31 in the 12 years old-group, 56 in the 11 years but 150 in the 9 years and 121 in the 6 years.

By applying to the sample of children (6 to 12) the same rules as in the "Normative Typology" (Figure 4) - the means of ratio between length and between heights of the curves - all groups belong to "Type A Normal". But inside each group some subjects belong to "Type B Lordotic" and other to "Type C Kyphotic".

Situation of the dorsal curve.

The value of $\bar{X}$ of DTI(5) who indicates the position of Top "D" is in all the age-group more than 100. It signifies that the depth (D-->F) of the dorsal part is greater than the height (h1) and is situated below the height.

The highest value are in the 8 years group DTI = 121 and 120 for the 6 years, while the lowest values are in the 10 years (101) and 9 years (103) and situated close to the height. All values are lower than in the Normative Group (140).

The size of the Radius Dorsal Curve is the smallest in the 6 years (RDC = 322mm) while it is the greatest in the 9 years (558mm).

The low value of RDC means that the curvature of the dorsal part is more accentuated.

The Coefficients of Variation of the RDC are the smallest in the 8 years V = 22 and the 12 years (29) while the greatest are in the 7 years (90) and 9 years (25).

Situation of the lumbar curve.

The values of $\bar{X}$ of LTI indicating the position of the Top "E" of the lumbar curve are greater than 100 but also greater than values indicating the Top "D" of the dorsal curve except of the 6 years where the values are practically the same (119-120), these are also the lowest in the lumbar curve.

The highest values appear in the 10 years (171), 9 years (170), 12 years (170), more than in the Normative Group (140).

TABLE I

Means ($\bar{X}$) and coefficient of variation (V) /V=(SD x 100) : $\bar{X}$/of Indexes of Children's Anatomical Spinal Curves and $\bar{X}$ of "Normative Group" (476F,M).

		Characteristics of both parts of Rachis				Dorsal parts			Lumbar parts		
		Dorso Lumbar Index (1)	Curve Relative Index (2)	Relative Summation Index (3)	Inclination Index (4)	Dorsal Top Index(5)	Dorsal Curve Index (6)	Radius Dorsal Curve (7)	Lumbar Top Index(8)	Lumbar Curve Index (9)	Radius Lumbar Curve (10
6 years	$\bar{X}$	195	193	8.5	4.2	120	8.5	322mm	119	7.5	159mm
	V	74.3	121.2	35.4	68.6	47.6	43.2	44.7	49.4	54.7	86.1
7 years	$\bar{X}$	166	144	10.6	4.7	110	8.1	466mm	133	10.2	141mm
	V	88.8	98.1	31.5	78.8	33.2	46.9	89.6	44.9	43.1	93.9
8 years	$\bar{X}$	168	130	8.5	4.3	121	7.4	364mm	147	8.8	169mm
	V	69.5	115.7	22.3	34.1	47	31.1	22.2	58.9	43.2	47.9
9 years	$\bar{X}$	260	217	7.8	4.9	103	7.1	588mm	170	8.7	144mm
	V	58.6	149.9	38.7	106.1	41.9	36.6	51.7	56.3	58.3	89.7
10 years	$\bar{X}$	192	145	8.4	5.2	101	7.7	420mm	171	16.9	169mm
	V	25.7	56.2	26.2	65.4	30.3	28.6	33.2	33.7	165.1	25.9
11 years	$\bar{X}$	236	166	8.2	8.7	106	7.6	459mm	152	9.3	154mm
	V	87.7	105.6	35.4	177.0	34.5	34.2	34.3	27.4	56.9	56.2
12 years	$\bar{X}$	196	140	9.8	3.9	118	8.6	398mm	170	12.3	152mm
	V	25.5	31.5	34.7	86.8	13.0	40.7	29.6	24.4	30.9	29.9
Norm.Gr. $\bar{X}$ (476♀♂)		215	202	9.9	7.0	104	9.7	460mm	140	10.5	202mm

The size of the Radius Lumbar Curve (RLC(10)) is in all age-groups smaller (twice to nearly four times) than the size of the Radius Dorsal Curve RDC(7).

But differences between the age groups are less than in the Radius Dorsal Curve. The smallest size of RLC is in the 7 years (141mm), the greatest is 169mm for 8 years and 10 years.

The Coefficient of Variation (V) of the RLC is the highest in the 9 years (90) and the lowest in the 10 years (26), where the RLC is greater than in Normative Group (140). The smallest variation in the position of the Top (E) is in the 12 years (V=24) and the greatest in the 8 years (59) and 9 years (56).

In general the variation in the Lumbar Top Index (E)-LTI (8) are greater than in the Dorsal Top Index (D)-DTI (5) and the evolution between the groups are moderate but irregular.

The above analysis has shown that there are great and irregular differences between the age-groups in the ratio of lengths of dorsal to lumbar curves DLI(1) and ratio of heights of dorsal to lumbar hights CRI(2). The differences inside the age-groups are important in the ratio length of dorsal to lumbar curve. But they are enormous in the ratio of heights of dorsal to lumbar curve.

The position of the Top of dorsal curve "D" DTI (5) and of the Top of the lumbar curve "E" LTI(8) evoluate irregularly from age-group to age-group. The changes of E - Top of lumbar curve are greater and increase from 119 to 170. Inside the age-group, in general the changes are more important for lumbar part "E" than for dorsal part "D".

The size of the Radius Dorsal Curve RDC (7) and the Radius Lumbar Curve RLC(10)/ with their Coefficients of Variation also change irregularly.

In spite of all this, the shapes of the spines with the means of each-group belong to "Type A Normal" in comparison with the Normative Typology but the values of the coefficient of variation show that in every age-group some children belong to Type B Lordotic or Type C Kyphotic.

The greatest variations exist in the 6 years and 9 years while smallest variations are in the 10 years and 12 years. It is a sign of stabilization.

In order to help to understand the multifactorial causes of these results Figure 6 presents "Individual Spherosomatograms" of two extreme cases for every age-group. Taking into consideration only 2 first indexes DLI (1), and CRI (2) compared with "Normative Typology for every sex" (Pig. 4), one notices that although the age-groups belong by means to Type A Normal, some cases are Hyperlordotic or Hyperkyphotic, which must be considered as deformation.

Interviews with the parents and the children have informed us that the children had an very early and intensive specialization in sport activities out of school.

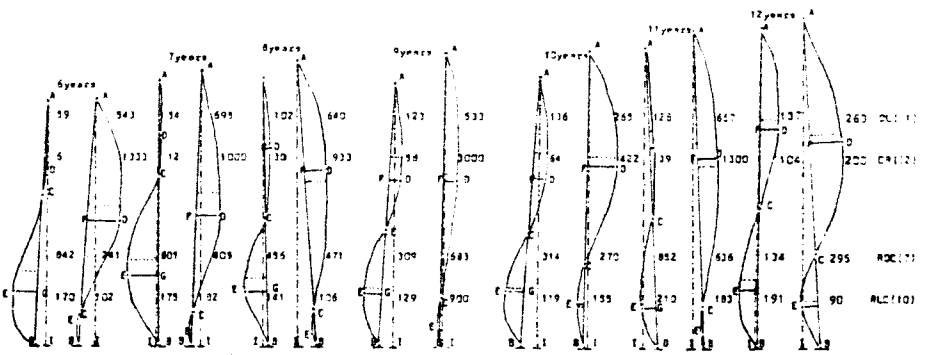

Figure 6: Individual spherosomatograms of cases of deformation (hyperlordosis and hyperkyphosis). /A._.I=vertical, A_B = cord, ... = h, D = top of Kyphosis, E = top of Lordosis.

CONCLUSION

Considering that abnormal deviation and deformation while appear in the profiles of the spinal curves of children, importance must be given to "specific psycho-motor-sport activities" specially during early biological development of the child.

The evolution of the Rachi-curves is a multifactor problem and it is necessary to make a fundamental study of the development of Rachi curves of a sufficient number of children which can be considered as a "Normative Group" in order to establish a Normative Typology for every age and sex.

In out-of-school-sport activities, in clubs, the child must be oriented in function of its capacities including the necessities of a normal biological development of the Rachi. In this matter, Physical Education, Sport and School Medicine have a fundamental responsibility.

Acknowledgement.

The author thanks Prof. J. Berthet for financial help received and Mr. Ch. Noens for his contribution to my research.

REFERENCES

WIELKI, CZ.,(1979). Vers une méthode électronique de mesure des courbures de la colonne vertébrale. Medecine du Sud Est. Paris. XV, 14 pp. 1223-1225.

WIELKI,CZ., (1983). Method for Measuring the Curve of the Spine by Electronic Spherosomatograph. Biomechanics VIIB,pp.1190-1187.

WIELKI, D., STURBOIS, X., and WIELKI, CZ. (1985). Classification of the anatomical spinal curves of female students in standing position. Biomechanics IXA,pp.263-268.

WIELKI,CZ., (1987). Anatomical functional deviation of the spinal curves of athletes. Biomechanics X.A,pp. 567-573.

WIELKI, CZ, ADRIAN, M. (1987). Aspect of spinal curve measurement of athletes. Biomechanics in Sports,III & IV,pp. 397-408.

WIELKI, CZ, KRUCHOSKI E.P (1990). Spinal curves of selected swimmers according to the stroke. Biomechanics in Sports VI, pp. 383-392.