

## Investigation of Sagittal Curves of Spinal Column and Establishing the Norm of Thoracic Kyphosis and Lumbar Lordosis

<sup>1</sup>Amin Allah Taheri Tizabi, <sup>1</sup>Reza Mahdavinejad, <sup>1</sup>Ali Azizi,  
<sup>2</sup>Teymour Jafarnejadgero and <sup>1</sup>Mostafa Sanjari

<sup>1</sup>Faculty of Physical Education and Sport Science, Isfahan University, Isfahan, Iran

<sup>2</sup>Faculty of Physical Education and Sport Science, Bu Ali Sina University, Hamadan, Iran

**Abstract:** The aim of this study was the investigation of sagittal curves of spinal column (Thoracic kyphosis and lumbar lordosis) in healthy boys with age between 12 to 17 years old. Thoracic kyphosis and the lumbar lordosis were evaluated in healthy boys by a flexible ruler with the child standing in a relaxed position. The sagittal curves were studied in 636 healthy boys between consecutive age-groups (12-13-14-15-16-17 ages) with a flexible ruler -a non-invasive device-with the child standing in a relaxed position. The accuracy and the reliability of this technique are studied and shown to be acceptable. Results revealed that the thoracic kyphosis and lumbar lordosis varied in deferent age-groups. The least pronounced kyphosis was seen at the age of 12 years and the least pronounced lordosis was seen at the age of 14 year. Analyses of variance (ANOVA) revealed significant differences between age groups in thoracic kyphosis ( $F(630) = 6.54, P=0.001$ ), but there was no significant differences between age groups in lumbar lordosis ( $F(630) = 0.960, P=0.442$ ). It was concluded that the mean range of kyphosis increase with increase of the age between 12-17 years in boys and we can use from finding of this study as the norm of thoracic kyphosis and lumbar lordosis.

**Key words:** Posture % Thoracic Kyphosis % Lumbar Lordosis % Flexible Ruler

### INTRODUCTION

The aim of this investigation was to study the alternation in kyphosis and lordosis during growth and establishing the mean range -norm- of thoracic kyphosis and lumbar lordosis. Establishment of the range of thoracic kyphosis and lumbar lordosis has mainly been performed with X-ray method, although there has been less study in the evaluation of spinal curves in the sagittal plane, most of this studies investigated lateral deviation of spinal column such as in scoliosis [1-4] and most of these studies didn't report about these physiological curves-lordosis and kyphosis- in the standing position. For example no details reported concerning mean range of kyphosis and lordosis in growing children. One reason for this deficiency in our knowledge of the posture of sagittal plane in the standing position of spinal column is the lack of simple, non-invasive and inexpensive device for describing and determining the norm-mean range- of these spinal curves [5].

Measurement of these curves in sagittal plane cannot be done with X-ray of the spine also this method cannot be used in screening and large population because it would not be safe for children and is not economical. For this purpose a flexible ruler - simple, inexpensive, safe and non-invasive device for measuring the degree of thoracic kyphosis and lumbar lordosis in the standing position-were used.

### MATERIALS AND METHODS

**Subjects:** 636 normal boys were voluntary to participate in this study. They were randomly selected from schools and divided to six age groups (12- 17 years). The participants that were investigated had no spinal column surgical history or scoliosis disorder.

**Measurement:** The sagittal plane of the growing spine was studied by flexible ruler. This instrument is described as a 40, 50 or 60 cm strip that covered with plastic, which

can be bent in one plane only and retains the shape into which it is bent[9]. Therefore, it can be used to copy any curved surface. Flexible ruler (flexi curve) was used to measure the degree of spinal curves. That can be placed on the spinal column to measure curves in the sagittal plane. The flexible ruler provides a quick, inexpensive and non-invasive way to assess posture in clinical, community or large population. Several investigators have established the validity of flexible ruler postural measures by correlating them with measures of kyphosis and lumbar lordosis taken from spinal radiographs and other instruments, such as goniometers, kyphometers and inclinometers [6-8, 2, 3, 10, 11]. Now this device is widely used to measure the degree of spinal curvature in the sagittal plane such as kyphosis and lumbar lordosis in physiotherapy and sport medicine field [8].

**Procedure:** For the spinal measurements, the flexible ruler is placed on the mid-line of the spine between two marked points ( $T_1$ , T12vertebrae for measurement of kyphosis and  $T_{12}$ ,  $S_2$  vertebrae for measurement of lordosis) [6, 12].

The measurement was performed with the subject standing in their usual relaxed posture, then flexible ruler was placed over the spinous processes of  $T_1$ -  $T_{12}$  for

measurement of thoracic kyphosis and  $T_{12}$ - $S_2$  for measurement of lumbar lordosis spine and shaped as spinal curves. The instrument was carefully removed and placed on a piece of plain white paper then the spinal curvature copied by a pencil along the flexible ruler and a vertical line was drawn to connect the  $T_1$  to  $T_{12}$  and  $T_{12}$  to  $S_2$  landmarks. Then by using the equation of ( $O = 4 \text{Arctang } 2H/L$ ) the degree of lumbar lordosis and thoracic kyphosis calculated. In this equation L is the straight line from the  $T_1$  to  $T_{12}$  and  $T_{12}$  to  $S_2$  vertebrae which was marked by the tester and the H is the distance between the deepest point of L line and the lumbar curve.

## RESULTS

The means, norm (mean range) and standard deviations of weight, height, thoracic kyphosis and lumbar lordosis in six age groups are from 12 to 17 years are shown in Table 1.

The means of the thoracic kyphosis and lumbar lordosis are shown in Table 1, Fig. 1 and Fig. 2. The means of the thoracic kyphosis increased with age development. The maximum mean degree of thoracic kyphosis is seen at the age group of 17 years. The minimum mean degree of thoracic kyphosis is seen at the age group of 12 years.

Table 1: The means, norm and standard deviations of weight, height, thoracic kyphosis and lumbar lordosis in six age groups.

	Age	N	Mean	Std. Deviation	Norm
Kyphosis	12.00	106	39.64	8.70	39.64±8.70
	13.00	106	43.21	9.37	43.21±9.37
	14.00	106	43.02	7.91	43.02±7.91
	15.00	106	43.69	8.32	43.69±8.32
	16.00	106	44.99	9.54	44.99±9.54
	17.00	106	46.02	8.67	46.02±8.67
	Total	636	43.43	8.96	43.43±8.96
Lordosis	12.00	106	44.96	10.27	44.96±10.27
	13.00	106	44.05	11.81	44.05±11.81
	14.00	106	42.27	11.18	42.27±11.18
	15.00	106	42.67	12.05	42.67±12.05
	16.00	106	43.08	11.30	43.08±11.3
	17.00	106	44.45	10.42	44.45±10.42
	Total	636	43.58	11.19	43.58±11.19
Weight	12.00	106	43.10	9.14	43.10±9.14
	13.00	106	45.62	10.58	45.62±10.58
	14.00	106	51.78	10.17	51.78±10.17
	15.00	106	58.46	13.82	58.46±13.82
	16.00	106	63.55	13.21	63.55±13.21
	17.00	106	65.21	12.76	65.21±12.76
	Total	636	54.62	14.43	54.62±14.43
Height	12.00	106	151.51	6.72	151.51±6.72
	13.00	106	156.41	7.85	156.41±7.85
	14.00	106	162.98	6.62	162.98±6.62
	15.00	106	166.80	8.55	166.80±8.55
	16.00	106	170.64	9.78	170.64±9.78
	17.00	106	172.97	6.62	172.97±6.62
	Total	636	163.55	10.85	163.55±10.85

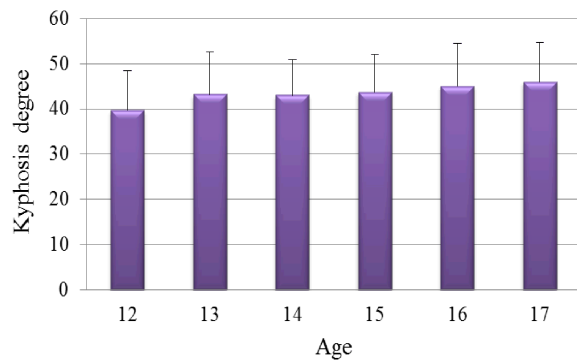


Fig. 1: Mean thoracic kyphosis

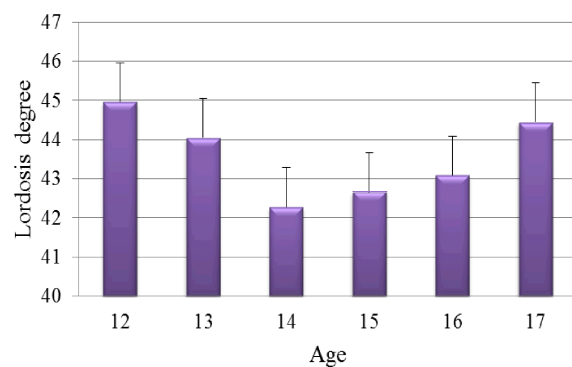


Fig. 2: Mean lumbar lordosis

Table 2: Analyses of variance (ANOVA) between age groups in thoracic kyphosis lumbar lordosis

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Kyphosis	Between Groups	2517.226	5	503.445	6.540	.000
Lordosis	Between Groups	601.762	5	120.352	.960	.442

Table 3: Tukey test between age group 1 and other age groups in thoracic kyphosis

Dependent Variable	(I) age	(J) age	Mean Difference (I-J)	Std. Error	Sig.
kyphosis	12.00	13.00	-3.56748*	1.20516	.037
		14.00	-3.37338	1.20516	.059
		15.00	-4.04592*	1.20516	.011
		16.00	-5.34489*	1.20516	.000
		17.00	-6.37404*	1.20516	.000

The maximum mean degree of lumbar lordosis is seen at the age group of 12 years. The minimum mean degree of lumbar lordosis is seen at the age group of 14 years. The mean ranges-norm- of thoracic kyphosis, lumbar lordosis considered as mean±one standard deviation.

The norm of kyphosis for 12 year age group was  $39.94 \pm 8.7$ , for 13 year age group was  $42.85 \pm 8.09$ , for 14 year age group was  $43.30 \pm 7.91$ , for 15 year age group was  $43.69 \pm 8.32$ , for 16 year age group was  $44.99 \pm 9.54$  and for 17 year age group was  $45.64 \pm 8.55$ .

The norm of lordosis for age groups 12 year was  $44.96 \pm 10.2$ , for 13 year age group was  $44.05 \pm 11.08$ , for 14 year age group was  $42.27 \pm 11.18$ , for 15 year age group was  $42.29 \pm 12.56$ , for 16 year age group was  $43.08 \pm 11.3$ , for 17age group was  $44.83 \pm 11.2$ .

Analyses of variance (ANOVA) revealed significant differences between age groups in thoracic kyphosis ( $F(630)=6.54$ ,  $P=0.001$ ), but there was no significant differences between age groups in lumbar lordosis ( $F(630)=0.960$ ,  $P=0.442$ ) (Table 2).

Table 3 shows Tukey test results between age group 1 and other age groups in thoracic kyphosis. Tukey test result indicate that differences between age group 1 and

other age groups in thoracic kyphosis Was statistical significant( $P<0.05$ ). Differences between age group 1 and age group 2 in thoracic kyphosis was not statistical significant ( $P>0.05$ ). Differences between age group 1 and age group 3 in thoracic kyphosis was statistical significant( $P<0.05$ ). Differences between age group 1 and age group 4 in thoracic kyphosis was statistical significant ( $P<0.05$ ). Differences between age group 1 and age group 5 in thoracic kyphosis was statistical significant ( $P<0.05$ ). Differences between age group 1 and age group 6 in thoracic kyphosis was statistical significant ( $P<0.05$ ).

## DISCUSSION

The increasing trend of mean range thoracic kyphosis (from 12 to 17 years) continued in boys. The results of this study about lumbar lordosis and thoracic kyphosis were consistent with study of Willner and Johnson [13]that were studied on thoracic kyphosis and the lumbar lordosis in 1101 healthy children in consecutive age-groups between 8 and 16 years of age. Their findings showed that mean range of kyphosis

increases with increase of age and mean range of lordosis decreases from 8 to 13 year then increase from 14 to 18 year [13]. About thoracic kyphosis majority of studies revealed that mean degree of thoracic kyphosis increases with age [9, 7, 14, 15]. Age-related increases in thoracic kyphosis can be attributed to overloading of spinal soft tissue, particularly to the intervertebral disk with ageing [16], or secondary to extreme physical activities, during the growth period [17]. Revel *et al.* [18] indicated that destructive changes at the spinal growth plate in rats that were submitted to repetitive physical activity underweight overloading conditions, But about lumbar lordosis mixed result were shown [9, 5, 13, 19].

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