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COMPARISON OF SAGITTAL PARAMETERS IN DIFFERENT MORPHOLOGICAL TYPES OF CERVICAL CURVATURE

COMPARAÇÃO DOS PARÂMETROS SAGITAIS NOS DIFERENTES TIPOS MORFOLÓGICOS DA CURVATURA CERVICAL

COMPARACIÓN DE LOS PARÁMETROS SAGITALES EN LOS DIFERENTES TIPOS MORFOLÓGICOS DE LA CURVATURA CERVICAL

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ABSTRACT

Objective: Evaluate and compare sagittal parameters of the spine in different morphological types of cervical curves. Method: ten lateral radiographs of the cervical spine of each morphological type of cervical curvature (lordotic, straightened, sigmoid and kyphotic) were used to measure the C1-C2 angle, C2-C7 angle using the Cobb method, T1 inclination, T1-lordosis inclination C2-C7 cervical and axial sagittal cervical axis. Parameter measurements were compared in the different morphological types of cervical spine curvature. Results: a statistical difference was observed in the C2-C7 angle, T1 inclination and T1 inclination-C2-C7 cervical lordosis in the different morphological types of cervical curvature. No statistical difference was observed in the C1-C2 angle and axial sagittal cervical axis in the different morphological types of cervical curvature.Conclusion: sagittal parameters (C2-C7 angle by Cobb method, T1 inclination, T1 inclination-C2-C7 cervical lordosis) present differences in the different morphological types of cervical curvatures and must be considered in the evaluation and therapeutic development. ***Evidence level III, retrospective comparative study.***

Keywords: Spine; Spinal Curvatures; Postural Balance.

RESUMO

Objetivo: Avaliar e comparar parâmetros sagitais da coluna vertebral nos diferentes tipos morfológicos das curvas cervicais. Método: Dez radiografias em perfil da coluna cervical de cada tipo morfológico da curvatura cervical (lordótica, retificada, sigmoide e cifótica) foram utilizadas para a mensuração do ângulo C1-C2, ângulo C2-C7 pelo método de Cobb, inclinação T1, inclinação T1-lordose cervical C2-C7 e eixo cervical sagital axial. As mensurações dos parâmetros foram comparadas nos diferentes tipos morfológicos da curvatura da coluna cervical. Resultados: Foram observadas diferenças estatísticas do ângulo C2-C7, inclinação T1 e inclinação T1-lordose cervical C2-C7 nos diferentes tipos morfológicos da curvatura cervical. Não foi observada diferença estatística do ângulo C1-C2 e eixo cervical sagital axial nos diferentes tipos morfológicos da curvatura cervical. Conclusão: Os parâmetros sagitais (ângulo C2-C7 pelo método de Cobb, inclinação T1, inclinação T1-lordose cervical C2-C7) apresentam diferenças nos diferentes tipos morfológicos das curvaturas cervicais e devem ser considerados na avaliação e elaboração terapêutica. ***Nível de evidência III, estudo retrospectivo comparativo.***

Descritores: *Coluna Vertebral; Curvaturas da Coluna Vertebral; Equilíbrio Postural.*

RESUMEN

Objetivos: Evaluar y comparar parámetros sagitales de la columna en diferentes tipos morfológicos de curvas cervicales. Métodos: Se utilizaron diez radiografías laterales de columna cervical de cada tipo morfológico de curvatura cervical (lordótica, rectificada, sigmoidea y cifótica) para medir el ángulo C1-C2, ángulo C2-C7 mediante el método de Cobb, inclinación T1, inclinación T1-lordosis C2-C7 eje cervical y axial sagital cervical. Se compararon las mediciones de parámetros en los diferentes tipos morfológicos de curvatura de la columna cervical. Resultados: e observó diferencia estadística en el ángulo C2-C7, inclinación T1 y lordosis cervical inclinación T1-C2-C7 en los diferentes tipos morfológicos de curvatura cervical. No se observó diferencia estadística en el ángulo C1-C2 y el eje cervical sagital axial en los diferentes tipos morfológicos de curvatura cervical. Conclusión: os parámetros sagitales (ángulo C2-C7 por método Cobb, inclinación T1, inclinación T1-lordosis cervical C2-C7) presentan diferencias en los diferentes tipos morfológicos de curvaturas cervicales y deben ser considerados en la evaluación y desarrollo terapéutico. ***Nivel de evidencia III, estudio comparativo retrospectivo.***

Descriptores: *Columna Vertebral; Curvaturas de la Columna Vertebral; Equilibrio Postural.*

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INTRODUCTION

The alignment of the cervical spine has aroused interest and been evaluated in numerous studies, and the definition of the normal morphology of the cervical spine remains undefined.[1-4] Cervical lordosis has been considered the natural curvature of the cervical spine; however, non-lordotic curvature has been observed in normal and asymptomatic individuals.[1,4,5,6]

The curvatures of the cervical spine have been classified into subgroups according to the relationship of the centroid of the C3-C6 vertebrae with the line joining the midpoint of the inferior vertebral plate of C2 and superior of C7.[7] The cervical spine is classified as lordotic when all the centroids are located in front of the line connecting C2-C7 ≥ 2mm; kyphotic when all the centroids are located posteriorly to the line ≥ 2mm; straightened when the centroids are located anterior or posterior to the line < 2mm from the line connecting C2-C7; and sigmoid when the centroids are located anterior or posterior to the line > 2mm. (Figure 1)

OBJECTIVE

The objective of the study was to evaluate and compare the sagittal parameters of the cervical spine in different morphological types of cervical spine curvature.

MATERIAL AND METHODS

The study was approved by the Ethics Committee of HCFMRP--USP under the number CAEE 81185724.4.0000.5440

Lateral cervical spine radiographs of 40 individuals were evaluated, with 10 individuals from each subgroup: 10 kyphotic cervical column, 10 lordotic, 10 sigmoid, and 10 rectified. The subgroups were considered according to the method that considers the distance from the centroids of C3-C6 to the line that connects the midpoint of the distal vertebral plate of C2 and the upper vertebral plate of C7. (Figure 1)

The parameters selected for the study were: C1-C2 angle, C2-C7, T1 inclination, T1 inclination - cervical lordosis and the sagittal cervical axis. (Figure 2)

Negative values (-) correspond to lordotic curvature and positive values (+) to kyphosis.

The statistical study was conducted using descriptive statistics, and the Kolmogorov-Smirnov test was used to assess the normality of the sample. The comparison of different methods was performed using the ANOVA test, Tukey test, and a significance level of 5% ($p<0.05$) was established.

RESULTS

Twenty-four individuals were female and 16 were male. In the kyphosis subgroup, 6 were female, 4 in the lordosis subgroup, 7 in the sigmoid subgroup, and 7 in the rectified subgroup. The average age of the 40 individuals was 40.63 ±16.29 years. In the group with lordotic curvature, it was 32.70±11.88 years; 49.40±14.56 in the rectified; 46±18.94 years in the sigmoid and 34.40±14.38 years in the kyphotic. No statistical difference was observed between the ages of the different types of kyphosis (ANOVA- $p<0.05$).

The values of angle C1-C2 and the descriptive statistics values of the four subgroups are illustrated in Table 1 and Figure 3. No difference in C1-C2 angulation was observed in the cervical spine subgroups. (Tukey test -p=0.3708)

The values of C2-C7 angulation by the Cobb method and the descriptive statistics of the values in the different types of cervical spine curvature are represented in Table 2 and Figure 4.

A statistical difference in the C2-C7 angulation was observed using the Cobb method in the cervical spine subgroups, except between the sigmoid and straightened types (ANOVA test).

The slope values of T1 and the descriptive statistics are illustrated in Table 3 and Figure 5. A statistical difference was observed between the subgroups except for the values of the sigmoid and rectified group.

The values of the difference between the inclination of T1 minus the cervical lordosis are represented in Table 4 and Figure 6. A statistical difference was observed between the subgroups with lordosis and kyphosis (ANOVA- $p<0.05$).

The values of the cervical sagittal vertical axis (CSVA) are shown in Table 5 and Figure 7. No statistical difference was observed between the different types of curvature of the cervical spine.

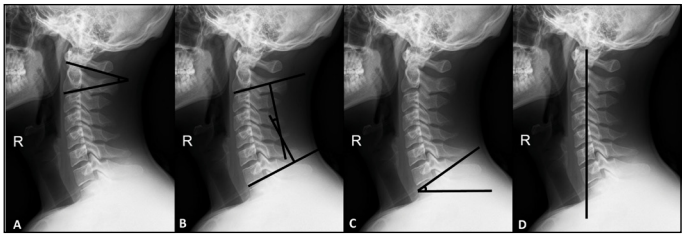

Figura 2. Cervical spine parameters selected for the study. A: C1-C2 angle. B: C2-C7 angle. C: T1 tilt. D: sagittal cervical axis.

Table 1. C1-C2 angle values in different types of cervical spine curvature.

	C1-C2			
	Kyphosis	**Lordosis**	**Sigmoid**	**Rectified**
Minimum	-40.2	-40.1	-37.9	-42.8
Maximum	-21.2	-16.7	-21.6	-20.7
Range	19	23.4	16.3	22.1
Mean	-30.86	-31.02	-29.63	-34.36
Std. Deviation	5.207	7.29	6.187	5.812

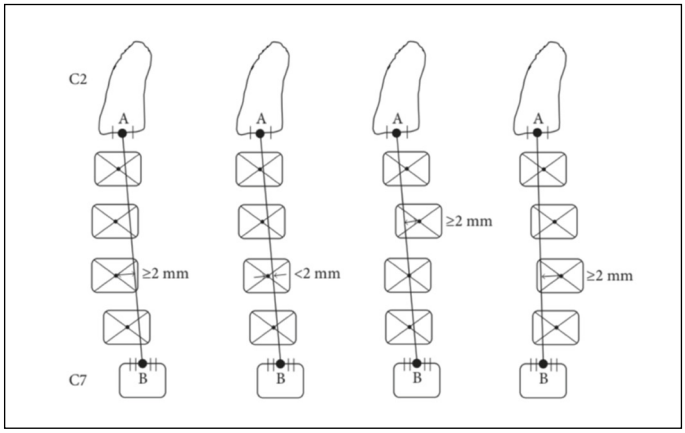

Figure 1. Drawing illustrating the 4 types of curvature of the cervical spine. From left to right: lordotic, rectified, sigmoid, and kyphotic.

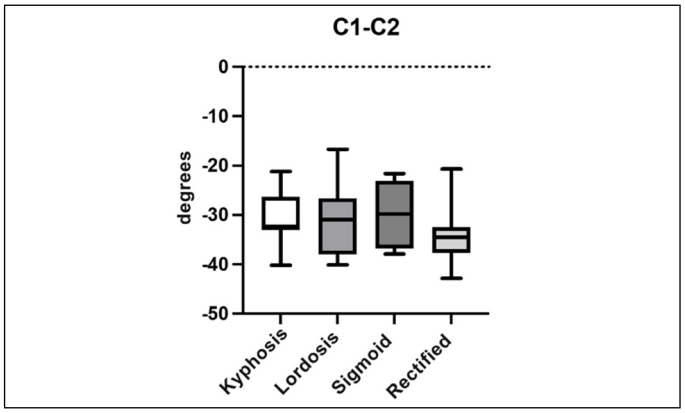

Figure 3. Graph illustrating the values of the C1-C2 angle in different types of cervical spine curvature.

Table 2. C2-C7 angle values in different types of cervical spine curvature.

	C2-C7.			
	Kyphosis	**Lordosis**	**Sigmoid**	**Rectified**
Minimum	-3.7	-51.5	-18.6	-15
Maximum	21.2	-8.9	-3.4	-0.3
Range	24.9	42.6	15.2	14.7
Mean	6.7	-23.47	-11.28	-4.93
Std. Deviation	7.08	11.87	4.668	4.166

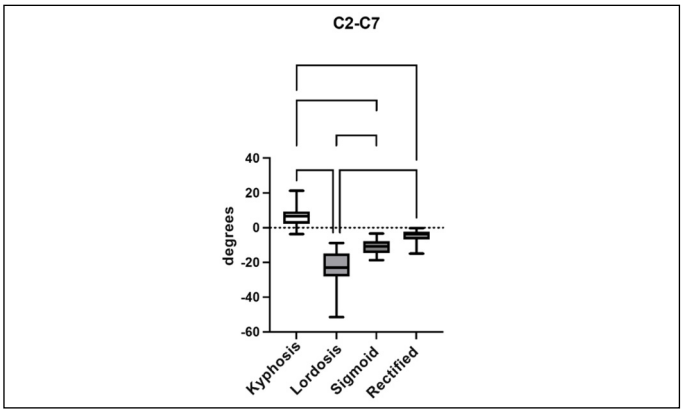

Figure 4. Graph illustrating the values of the C2-C7 angle in the cervical spine subgroups. The asterisk (*) indicates statistical difference (ANOVA- $p<0.05$).

Table 3. Inclination values of T1 in different types of cervical spine curvature.

	T1 slope			
	Kyphosis	**Lordosis**	**Sigmoid**	**Rectified**
Minimum	7.7	26.6	19	12
Maximum	32.6	42.9	35.8	35.4
Range	24.9	16.3	16.8	23.4
Mean	19.07	33.69	27.7	24.55
Std. Deviation	7.245	6.063	4.535	7.506

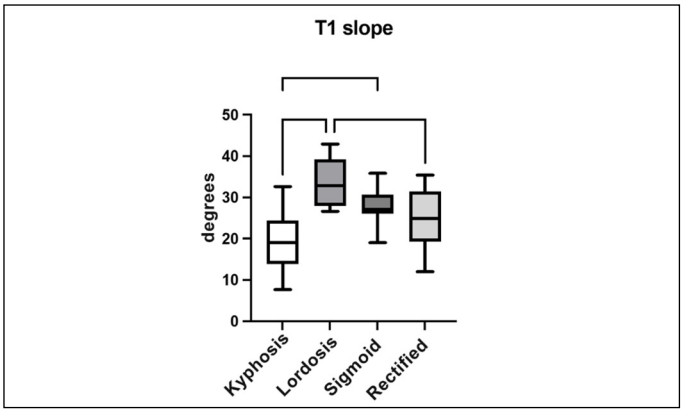

Figure 5. Graph illustrating the inclination of T1 in different types of cervical spine curvature. The asterisk (*) indicates statistical difference (ANOVA-$p<0.05$).

Table 4. Values of the difference in T1 slope and cervical lordosis in different types of cervical spine curvature.

	T1-CL			
	Kyphosis	**Lordosis**	**Sigmoid**	**Rectified**
Minimum	18.6	2.8	9	8.3
Maximum	40.3	28.6	28	30.6
Range	21.7	25.8	19	22.3
Mean	25.75	11.92	16.4	19.64
Std. Deviation	6.776	9.375	6.267	6.502

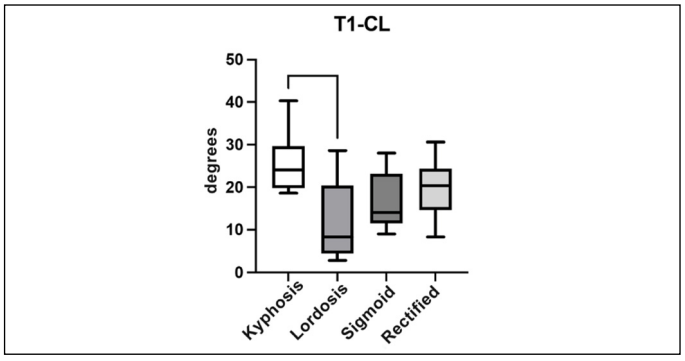

Figure 6. Graph illustrating the values of T1 slope minus cervical lordosis in different types of cervical spine curvature. The asterisk (*) indicates a statistical difference (ANOVA – $p<0.05$).

Table 5. Sagittal vertical cervical axis (CSVA) values in different types of cervical spine curvature.

	CSVA			
	Kyphosis	**Lordosis**	**Sigmoid**	**Rectified**
Minimum	9.8	2.5	-11.2	2.7
Maximum	38.4	35.1	24.5	42.1
Range	28.6	32.6	35.7	39.4
Mean	25.34	17.06	12.36	25.2
Std. Deviation	10.23	11.14	10.07	12.06

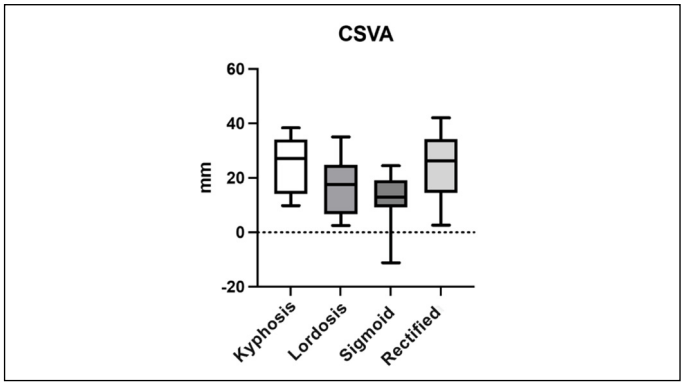

Figure 7. Graph illustrating the cervical sagittal vertical axis (CSVA) values in different types of cervical spine curvature.

DISCUSSION

The sagittal parameters of the cervical spine showed a statistical difference between the different types of cervical spine curvature, except for the C1-C2 angle and the cervical sagittal vertical axis (CSVA).

The lordosis of the cervical spine has been considered as the physiological curvature, although the definition of the physiological alignment of the cervical spine remains undefined. The presence of cervical spine kyphosis in asymptomatic individuals, and reports of lordosis in only about 30% of asymptomatic individuals have been presented in reports.[5,7-10] Evidence indicates that the morphology of the cervical spine in asymptomatic individuals shows a wide variation from lordosis to kyphosis, and simple observation of cervical kyphosis without clinical symptoms should be analyzed with caution. Although cervical spine kyphosis is physiological in a certain percentage of the population, this observation does not support planning kyphosis in surgeries.[7] Patients undergoing cervical arthrodesis with maintenance or increase of lordosis in the arthrodesed segments show better clinical outcomes.[11,12]

In our study, we used the modified Toyama method for classifying different types of cervical spine curvature: lordotic, straightened, sigmoid, and kyphotic.[7] Normal individuals have different morphologies of cervical spine curvature, and different classification proposals have been presented to characterize the different types.[5,13-15]

The C1-C2 segment contributes 77% to the constitution of cervical lordosis and the C2-C7 segment contributes 23% according to the observation of 100 asymptomatic individuals.[16] We observed a statistical difference in the C2-C7 angulation among the different morphological subgroups of cervical curvature, which represents an expected result due to morphological differences. However, no difference was observed in the C1-C2 angulation between the different groups, contrary to the expected result, considering the concept of the participation of the C1-C2 segment in the formation of the curvature of the cervical spine.

We used the Cobb method for measuring cervical curvature (C2-C7). The Cobb method has been the most used for measuring cervical curvature, although other methods (Harrison Method, Jackson method) have been proposed. The Cobb method may underestimate the measurement of cervical lordosis due to the orientation of the C2 vertebral plate.[7]

Determining cervical curvature using the Cobb method. The difference in T1 slope between the different morphological types of cervical spine curvature, and more evidently between the kyphotic type, corroborates reports of the correlation of greater T1 slope with a higher degree of cervical lordosis.[17] The great mobility of the cervical spine allows for compensation of caudal misalignments, and the T1 slope can express the increase in thoracic kyphosis. The reduction of thoracic kyphosis decreases the angular value of T1 inclination and is related to cervical spine kyphosis.[17]

The study presents limitations related to the sample size and the possible difference between the sexes. Although the age among the different groups did not show a statistical difference, it was not possible to obtain a homogeneous distribution regarding the sexes, and there are reports evidencing the difference in cervical sagittal parameters between the sexes.[7,15] Other parameters covering the occipital (occipito-C2 angle, cranio-spinal angle) have been included in the evaluation of the sagittal parameters of the cervical spine were not considered in our study.

The use of T1 slope minus cervical lordosis was introduced due to the importance of the relationship between T1 slope and cervical lordosis in characterizing cervical spine misalignments.[18] The observed difference between the kyphosis and lordosis subgroup expresses the difference between the two parameters (T1 slope and cervical lordosis) between the two subgroups. The inclination of C2 was not used in our study, and it has been correlated with the difference in T1 inclination and cervical lordosis. The inclination of C2 shows a strong correlation with the difference in the inclination of T1 and cervical lordosis, and could be used as a marker of the global alignment of the cervical spine.[19]

The cervical axial sagittal axis (cSVA) corresponds to the distance from the vertical line of the center of C2 to the posterior edge of C7, with values ranging from 0.5 to 2.5 cm being reported as normal, and 4 cm considered the limit for moderate disability.[16] No difference was observed between the subgroups and the values are in accordance with the variation spectrum reported in the literature.[16,17] High cSVA values are correlated with a high cervical disability index.[17]

Study limitations

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CONCLUSION

The observed results illustrate the morphological heterogeneity of the cervical spine curvatures in asymptomatic individuals. The morphology of the curvature of the cervical spine and its respective sagittal parameters should be considered in the patient's evaluation and therapeutic planning with the aim of correcting and maintaining the physiological alignment of the cervical spine.

All authors declare no potential conflict of interest related to this article.

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