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Evaluation of lumbar intersegmental range of motion using flexion-extension radiographs of asymptomatic versus low back pain adults

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In this descriptive study, active lumbar flexion-extension radiographs of low back pain patients and asymptomatic volunteers were evaluated. The radiographs were evaluated to assess differences between the two groups using intersegmental angular and translational measurements. Average differences for angular and translational ranges of motion between groups were found, with a lower range of motion affecting the low back pain group. Subjective definitions of hypo and hypermobility were also offered to evaluate their prevalence within the samples.
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KEY WORDS: range of motion, flexion-extension, lumbar spine, low back pain.

Cette étude porte sur la comparaison de radiographies lombaires prises en flexion-extension active, sur des patients symptomatiques c. asymptomatiques. Sur les radiographies, des mesures furent prises pour mesurer, de façon intersegmentale, les translations et les angles vertébraux. Puis, ces mesures furent comparées entre les deux groupes (symptomatiques c. asymptomatiques). Une différence constante fut remarquée entre les deux groupes, le groupe souffrant de douleurs lombaires ayant la mobilité segmentale la moindre. On tente d'expliquer ces différences en parlant d'hyper et d'hypomobilité.
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MOTS-CLÉS : degré de mobilité, flexion-extension, lombaire, douleur lombaire.

Introduction

Methods of evaluating the lumbar spine segmental ranges of motion have been of interest to many chiropractic researchers trying to find a relationship between joint movement and low back pain. These methods have included qualitative and quantitative analysis of lumbar motion.[1–6] One method described by Hanley et al. involved a technique that assessed the range of motion using a template method of analysis. The method provided a new way of assessing the clinical biomechanics of the spine. Scientists started to gain an appreciation of the normal patterns of motion present in a healthy spine. As a result, movement patterns greater than normal were considered to be evidence of instability. Instability thus became known as a radiographic diagnosis. However, there is no radiographic evidence defining hypo and hypermobilities of the spine in a clinical context.[2,8,9]

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Various problems have hindered the continuance of research in this area, such as disparity in the protocols of examination, low levels of radiographic interexaminer reliability[4,10] and ethical concerns when using asymptomatic volunteers. Nevertheless, the quantification of intersegmental ranges of motion may be helpful in gaining a better understanding of the lumbar spine. Therefore, the purpose of this study was to test the hypothesis that statistically significant ($p < .005$) lower angular and translational ranges of motion occur in the lumbar spine of symptomatic patients as compared to asymptomatic individuals.

Methods and materials

Forty-four subjects between 20–30 years of age were recruited with a gender distribution of thirty-three males and eleven females. Twenty-two symptomatic patients were selected from the Canadian Memorial Chiropractic College outpatient clinic population with a diagnosis of mechanical low back pain. This diagnosis describes a condition where a clinical restriction in the lumbar range of motion is found without evidence of neurological finding. The asymptomatic group included twenty-two volunteers from the chiropractic college student population with no previous history of low back pain.

Each subject underwent a standing, radiographic examination which consisted of a frontal spot view as well as neutral lateral, flexion and extension images of the lumbar spine. A single phase radiographic unit was used with 400 speed rare earth screens at 100 cm focal-film distance. Each individual was instructed to bend backward and forward until "hanging loose" at the time of the exposure. The spot view and lateral projection were analyzed to diagnose any anomalies listed as exclusion criteria. A brief explanation was given including the fact that approximately 3 rads were to be deivered to the lumbar region, even though the reproductive organs would be spared because of effective shielding. Following this explanation, written informed consent was obtained. Subjects that were excluded from the study were those demonstrating radiographic evidence of congenital anomalies, spondylolisthesis and degenerative disc or joint disease.

Measurements

The included films were used to measure three segmental variables with the template method of measurement.[2,7] Angular motion (in degrees) and translations (in mm) on the posterior-superior and posterior-inferior aspects of each vertebra were measured at the L3–4, L4–5 and L5–S1 levels (Figure 1). Each template was constructed by drawing a full outline of the outer cortical margins from the extension radiograph of the lower lumbar vertebrae and sacral base. The flexed segments were then outlined onto the transparency after closely aligning the subjacent vertebrae. Intersegmental anglular ranges of motion were measured from lines drawn parallel to the inferior end plate of one vertebra from flexed to extended positions. Translation A was measured from the posterior inferior border of the vertebra in flexion to the same landmark in the extended position. Trans-

Radiographic Analysis of Segmental Motion

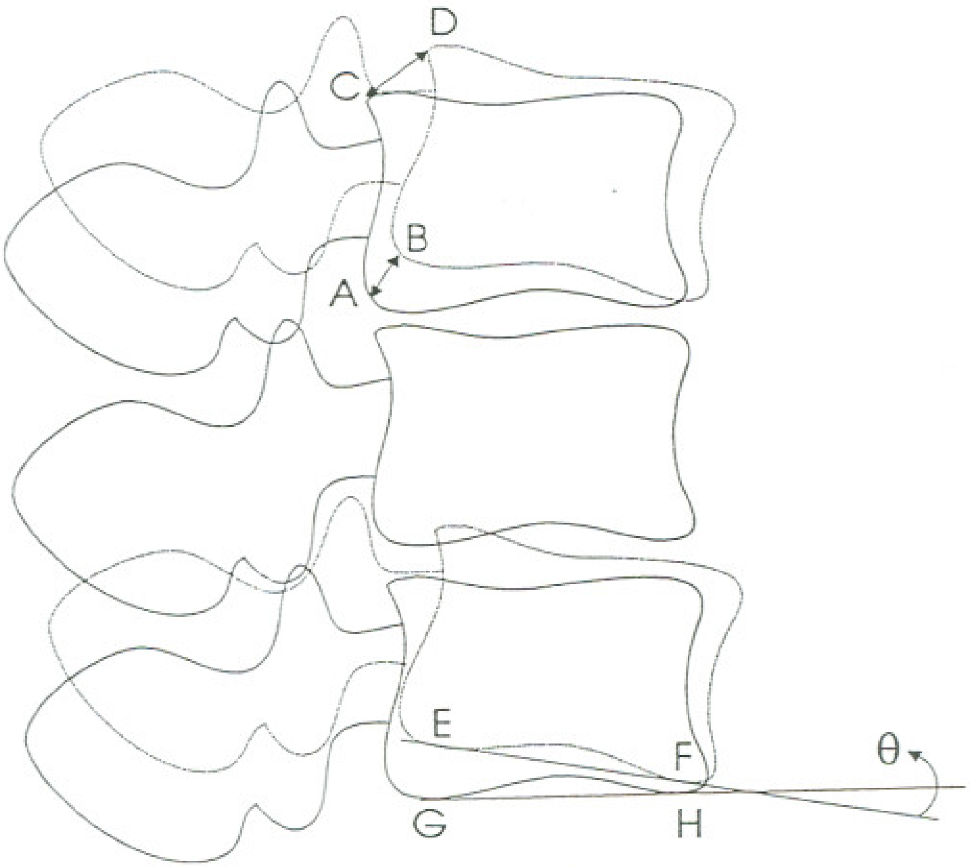

Figure 1 Landmarks used to measure:
Translation A: distance A-B (mm)
Translation B: distance C-D (mm)
Angular ROM, angle from lines E-F and G-H

lation B was the distance measured in millimeters from the posterior superior aspect of one vertebra in flexion to the same landmark in extension. All measurements were taken from L3 to L5. The assessor was blinded as to which samples were drawn from asymptomatic or symptomatic subjects and repeated the marking of five subjects chosen at random to determine intra-examiner reliability.

The data were grouped into symptomatic and asymptomatic categories and into spinal level subcategories. This layout enabled a multifactorial ANOVA to be conducted to test the statistical significance of our categories and their interactions. A quantitative definition of hypo and hypermobility as the mean measurement plus or minus one standard deviation (66% of the distributions) of the asymptomatic group was given for both the angular and translation B variables. From these definitions, frequency tables were built to suggest the prevalence of hypo and hypermobilities at large and at their targeted levels. The intraclass correlation coefficient was used to assess the intra-examiner reliability for the ranges of motion measurements. Contingency coefficient analyses were also performed to determine the nature of the association between symptom status and the prevalence of abnormal motion patterns.

Results

The descriptive statistical analyses of the data revealed lower averages for the angular and translational ranges of motion in the symptomatic group (Table 1). The multifactorial ANOVA revealed no statistical significance for the different ranges of motion between levels or for the interactions between the grouping and the levels (Table 2). The Tukey's post-hoc test was used to calculate a more severe statistical difference between the control and symptomatic group means for the angular and translation measurements (Table 3). The results showed 3.44 degrees and 2.98 mm as the mean differences for angular and translation B motions to achieve statistically significant differences between the symptomatic and asymptomatic groups. The intra-examiner reliability coefficient (ICC) was .77 using angular and translational measurements. The power calculated with an alpha value of .025 and a two tailed distribution was greater than 80% for angular motion and translation B. Twenty-eight subjects were needed to achieve a power greater than 80% for the results about translation A.

The normal angular range of motion (ROM) per segment was calculated at 9 to 20 degrees and the normal translation B range of motion from 9 to 18 mm. Any value measuring less than 9 degrees (angular motion) or 9 mm (translation B motion) was judged to indicate hypomobility. Values measuring 20 degrees and more or 18 mm and more were classified as indicating hypermobility.

Discussion

It is clear that this study has its own limitations due to the type of equipment used: single plane radiography has been reported to have higher error rates[11] and the active motion protocol inhibits the sensitivity of the results. The absence of digital methods to obtain data was also regarded as an additional source of error.[1] Nevertheless, the intent of this paper was to quantify distinct normal and abnormal ranges of motion of the lumbar spine. Previous articles[2] have shown lower ranges of motion for low back pain groups, as suggested by t-tests.

From our results, it appears that a statistically significant intersegmental difference of 3.44 degrees and 2.98 mm for the

Table 1
Description of the segmental motion in the asymptomatic and symptomatic groups

	Asymptomatic group	Symptomatic group
Angular ROM		
Mean (degrees)	15.11	11.67
Standard deviation	5.70	6.24
Translation A		
Mean (mm)	4.73	3.58
Standard deviation	2.20	2.66
Translation B		
Mean (mm)	13.43	10.45
Standard deviation	4.61	5.42

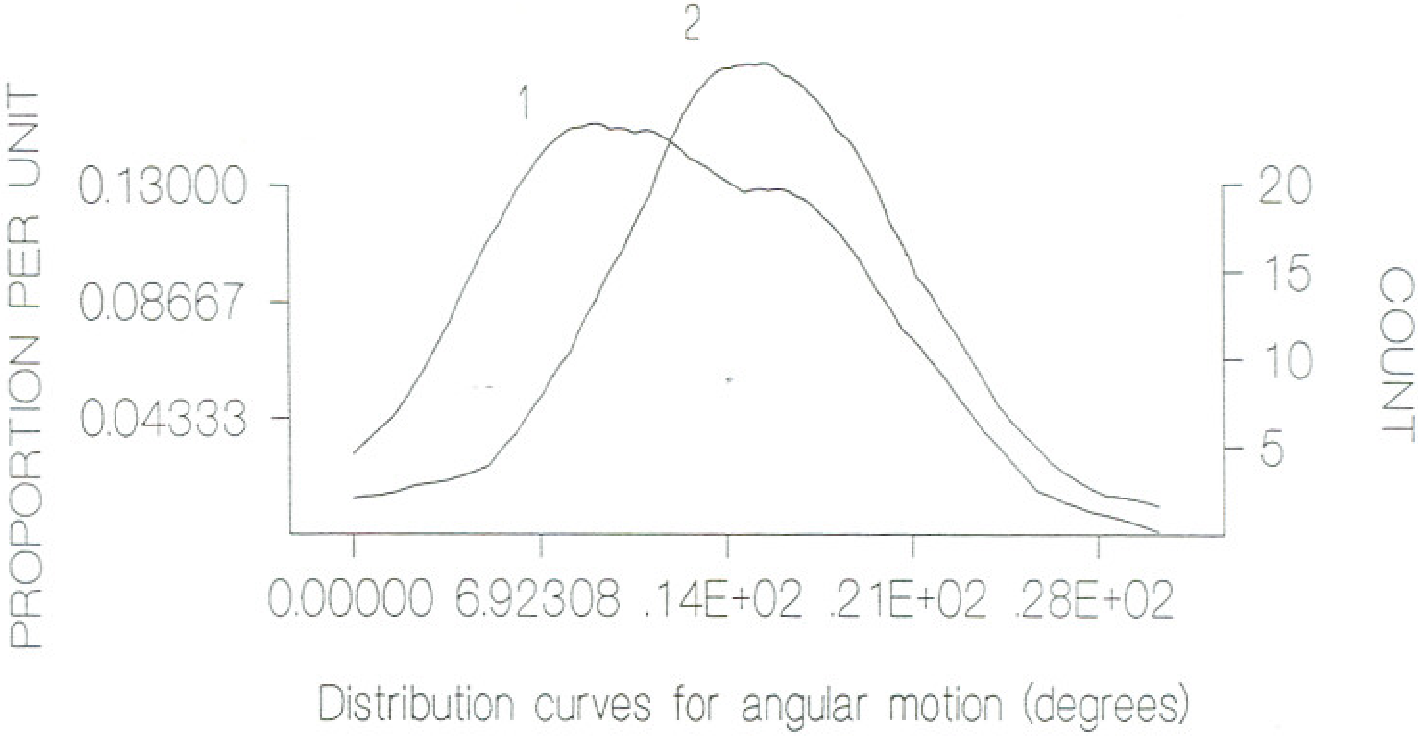

Figure 2 Distribution curves for low back pain (1) and asymptomatic (2) group showing lower placement of the symptomatic group.

Table 2
Summary of the ANOVA tables for the 3 variables: group, level and interaction

Source	Group	Level	Interaction
Angle	$p < .005$	$p > .3$	$p > .1$
Translation A	$p < .005$	$p > .4$	$p > .4$
Translation B	$p < .005$	$p > .7$	$p > .3$

Table 3
Summary of the differences and power between the control and low back back pain groups for the 3 variables

Post-Hoc tests	Angle	Translation A	Translation B
Tukey's HSD mean difference	3.44 degrees	1.15 mm	2.98 mm
Minimum required for significance	2.36 degrees	.96 mm	1.99 mm
Power	85%	67%	87%

angular and translation B measurements respectively, may prove not to be sufficient for clinical interest. These modest differences can be explained by the generous overlap between the asymptomatic and symptomatic distribution curves (Figure 2). The intra-class coefficient of reliability was acceptable but the high standard error of the measurements using a methodology involving specific radiographic landmarks questions its clinical utility. Nevertheless, the results of this paper are in agreement with similar studies.[2] Lower ranges of motion are found in the low back pain group and the level presenting with the highest prevalence of hypomobility was found at L4–5.[6]

The arbitrary definition and use of hypo and hypermobility to define cut-off points did not enable distinct boundaries and relationships between the symptomatic and asymptomatic groups. It is, however, evident that hypomobilities are more frequent in the low back pain group in both angular and translation B ranges of motion, while hypermobilities are more common in the asymptomatic group (see Figure 3). The coefficients of determination reflected the overlap of the distribution curves and showed that any change in symptom status was responsible for only 19% of the changes in overall angular range of motion. The strength of association between clinical status and aberrant motion patterns was also more noticable at the L4–5 level with a 50% coefficient of determination (Tables 4 and 6). In Table 5, the sum of the percentages for a given measurement method may be more or less than 100% since several subjects presented with more than one type of aberrant motion across all spinal levels.

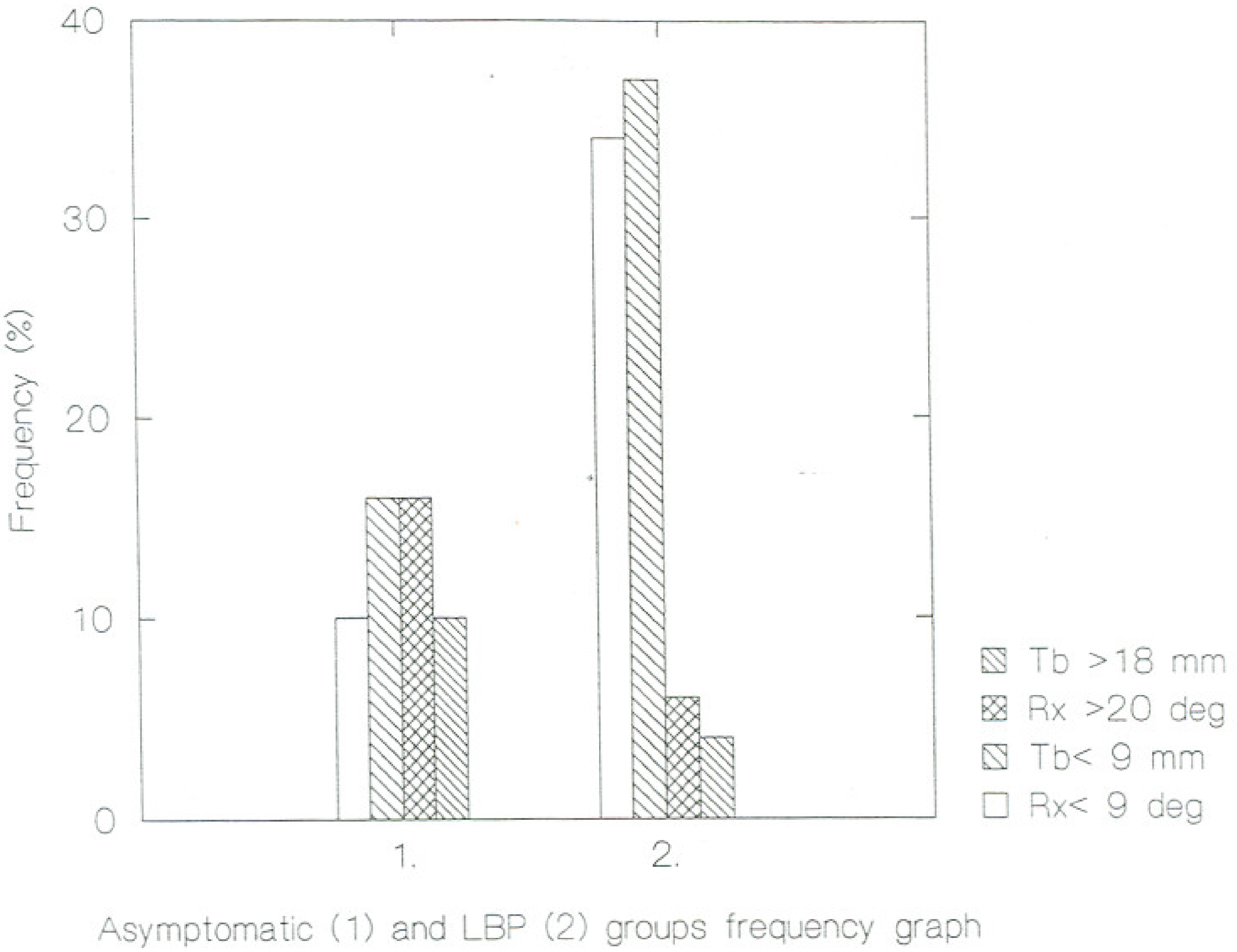

Figure 3 Highest prevalence for angular (Rx) and translation B (Tb) hypomobility is found in the low back pain group.

Table 4
Prevalence for hypomobilities and hypermobilities as defined for angular and translation B ranges of motion. Coefficient of contingency (C) and coefficients of determination (C^2) listed for the corresponding variables.

Grouping Variables	Asymptomatic group Hypo	Hyper	Low back pain group Hypo	Hyper	C	C^2
Angle	7/66 (10%)	11/66 (16%)	23/66 (34%)	4/66 (6%)	.435	19%
Translation B	11/66 (16%)	7/66 (10%)	25/66 (37%)	3/66 (4%)	.316	10%

Table 5
Aberrant motion frequency table per spinal segment.
Prevalence for hypomobilities (HO) and hypermobilities (HE) as defined for angular and translation B ranges of motion among the asymptomatic and low back pain categories.

Grouping Level	Asymptomatic group L3–4	L4–5	L5–S1	Low back pain group L3–4	L4–5	L5–S1
Angular HO	14%	0%	18%	32%	41%	31%
Angular HE	4%	27%	18%	4%	0%	13%
Translation B HO	13%	13%	27%	36%	41%	36%
Translation B HE	4%	4%	9%	4%	4%	4%

Table 6
Coefficients of contingency (C) and determination (C^2) for segmental distributions

Variables Level	Angular motion C	C^2	Translation B C	C^2
L3–4	.292	8.5%	.17	3.0%
L4–5	.707	50.0%	.256	6.5%
L5–S1	.41	16.8%	.357	12.7%

Conclusion

Our findings revealed subtle relationships between symptom status and ROM but failed to display a strong association between clinical presentation and abnormal motion patterns. One may suggest that intersegmental loss of ROM reflects an antalgic state, pin-pointing the motor unit presenting with clinical mechanical dysfunction. Even though not assessed, inherent factors to this study such as height, weight, fitness level, may have affected symptom status and ROM. Nevertheless, many patients showed decreased motion at L4–5 while hypermobility at the same level was more dominant within the asymptomatic group. Interestingly, very few hypermobilities were found in the symptomatic group and one may speculate as to their true population prevalence, as antalgia is associated clinically to lower ROM.

We consider these results insufficient to provide definitive ranges of motion relating to a specific clinical status because of the overlap encountered in the distribution curves. Future research should try to solve the different problems related to the radiological protocol and undertake Receiver Operator Curves (ROC) analysis to classify individuals into groups according to physical markers, clinical status and ROM patterns. ROC may be helpful to establish clinical, structural and ROM cutoff points now that the coefficients of contingency have indicated associations between symptomatology and amplitudes of motion.

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