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A Retrospective Consecutive Case Analysis of Pretreatment and Comparative Static Radiological Parameters Following Chiropractic Adjustments

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ABSTRACT

An investigation was undertaken to determine the effect of chiropractic adjustments on static radiological parameters. Standard plain film radiography was used. A retrospective consecutive case analysis approach was used for obtaining the data from the pretreatment and comparative posttreatment radiographs. Measurements for cervical lordosis, sacral base angle, lumbar lordosis, scapular angle, Cobb's angle and retrolisthesis of adjusted lumbar segments were determined by marking films in a blinded fashion. Intra- and interexaminer reliability for the measurement of cervical lordosis and retrolisthesis were determined to be excellent with a low standard error (Pearson's r range 0.89–0.97, $p < .001$ for cervical lordosis and Pearson's r 0.74–0.90, $p < .001$ for retrolisthesis). The data from pre- and comparative post-measurements of retrolisthesis showed a significant reduction of approximately 34%. No reduction was seen in a control group with retrolisthesis. No pre/post comparative changes were observed with cervical lordosis angle, sacral base angle, lumbar lordosis angle, scapular angle or Cobb's angle. (J Manipulative Physiol Ther 1990; 13:498–506).

Key Indexing Terms: Chiropractic, Lumbar Spine, Radiography, Scoliosis.

INTRODUCTION

Many health care providers use static alterations of the sagittal curves and other alignment properties of the human spine as a source for objective criteria in assessing spinal pathology (1–4). Additionally, stress radiography (2, 5, 6) and videofluoroscopy (7) have been used to analyze dynamic alterations of spinal function. The radiographic examination is usually supplemented with a clinical evaluation since radiographic alignment abnormalities, unless quite large, are not considered noteworthy (8).

Chiropractors, more than any other health care discipline, have been proponents for the claim that static spinal intersegmental dysarthrias (positional dyskinesia), and postural changes in either the coronal or sagittal plane are clinically relevant and serve as evidence that a patient may require spinal adjustive therapy (SAT) (9–11). While there are many individual case reports and studies of a nonblinded nature pertaining to improvement in static spinal alignment following spinal adjustive therapy (9, 11–14), a review of the literature has failed to elucidate any randomized, blinded, consecutive case or controlled investigations.

The purpose of this study was to determine the effect, if any, of chiropractic adjustments on the intersegmental and postural static relationships of the human spinal column. This investigation is based on the assumption that standard plain film radiographic images are an adequate means of evaluating static intersegmental and postural alignment.

MATERIALS AND METHODS

Patient files and X-rays were obtained by selecting the first 25 patients who entered the practitioner's office between January 1, 1986 and March 1, 1986 who had subsequent pre and comparative films taken during the course of their treatment. Similarly another consecutive case sampling of 25 patients was obtained from April

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1. 1986 through June 1. 1986. Both samples were combined for the statistical analysis. Two hundred total films were analyzed. consisting of 50 sets of pre and comparative lateral and 50 sets of pre and comparative anteroposterior (AP) full spine radiographs. Fifty patients were evaluated: each had four exposures. This represents an average entrance skin dose of 0.85 Rad per patient. No attempt was made to preselect the films by either the assistant or the doctor before their retrieval.

Lateral full spine radiography consists of two exposures taken on one X-ray film measuring 14 in × 36 in. The focal film distance (FFD) for each exposure was 80 in and the anteroposterior full spine film was taken with one exposure at a focal film distance of 80 in. Rare earth intensifying screens and aluminum wedge filtration were used during the examination to reduce radiation exposure (15). A high kilovoltage technique (average 90 kV) was used. which also decreased the entrance skin dose received by the patient when compared to lower kV techniques. The Bolin filtration system provided gonadal and breast shielding.

Patient placement for the examination was standardized by the practitioner. For the AP film. a foam wedge was placed at the back portion of the skull between the occiput and bucky in order to keep the patient close to the bucky and steady. The subject's feet were evenly placed approximately 6–7 in apart. equidistant from the center of the bucky. The back of the heels were parallel to the front edge of the bucky. The patient rested his/her arms upon a solid bar during the lateral exposure. No other restraining devices were used. The X-ray equipment was vertically and horizontally aligned.

Consistency of patient positioning was the reason for choosing the practitioner. As this was a retrospective study. the authors were not present during the examinations. but the patient placement and radiographic technique were demonstrated to the authors. In another report. it was concluded that patient placement could be repeated and standardized in the weight-bearing position. and this produced very similar anatomical images on the X-ray film (16). The reproducibility of patient placement by this particular practitioner was not tested in this investigation. The treating doctor routinely performed comparative (pre and post) radiographic examinations. This comparative examination was used as a means for assessing patients' progress or response to spinal adjustment. and as a source of information in determining the correct loci and direction of forces in subsequent spinal adjustments. The radiological examination was preceded by a clinical assessment including motion palpation. static palpation and skin temperature instrumentation analysis (17).

The form of spinal adjustment performed was a specific short lever arm procedure consisting of a high velocity and short amplitude thrust. Immediately following the thrust the short lever arm being contacted was held for approximately 1–2 sec. The emphasized direction of force employed by the doctor was +Z translation (posterior to anterior). This +Z translation is particularly stressed in the lumbar spine. The details of the adjustive technique. including patient placement for the treatment. have been described elsewhere (9).

After the films were selected. they were sent to an independent examiner. All information on the films. including patient identification. was covered and pertinent pencil markings were erased. The examiner had no knowledge about which was the initial and which was the comparative film. However. both films were always on the illuminator at the same time to make it easier to determine anatomic points on each film.

A number of variables were analyzed on the pre- and post-films. Markings were made on the radiographs to ascertain millimeters of retrolisthesis of the adjusted lumbar segment. This procedure consisted of making a dot at the anterosuperior and one at the posterosuperior corner of the subjacent vertebral body. The superior segment then had a dot placed at the posteroinferior corner of it's vertebral body. The subjacent dots were then connected with a line. and another line was descended at the posterosuperior point perpendicular to the horizontal line. A parallel line was then descended from the superior segment and the distance separating the two lines was measured (Figure 1).

The examiner had a copy of the progress notes of the patient in order to determine the adjusted lumbar segment. Patients who had spondylolisthesis. antalgic po-

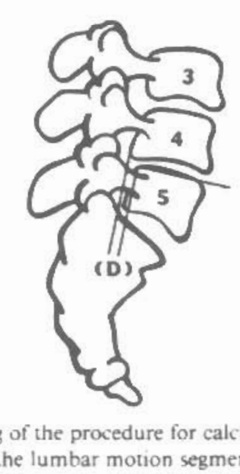

Figure 1. A drawing of the procedure for calculating the amount of retrolisthesis (D) for the lumbar motion segment.

sitions and/or films of poor diagnostic quality, making marking difficult, were excluded from the lumbar marking procedure ($n = 5$). The retrolisthesis measurement was the only intersegmental analytical procedure. As a control for the intersegmental marking, another 23 patients were selected. Nonadjusted posteriorly displaced segments were analyzed. These were patients who did not have lumbar adjustments between examinations ($n = 5$) or who had a posterior segment at least two vertebrae away from the adjusted level ($n = 18$). These two groups were then analyzed for translation positional change along the Z axis. All measurements were rounded to the nearest 0.5 mm. It was reasoned that this was the maximum precision possible due to the width of the pencil line.

Interobserver reliability for the retrolisthesis measurement was determined with three examiners and 20 different cases. One examiner marked 20 cases again to determine intraexaminer reliability. Standard errors of estimate and 95% confidence intervals were calculated in addition to the reliability coefficient (Table 1). The retrolisthesis measurement was determined to have excellent intraexaminer reliability (Figure 2).

The issue of patient placement and its effect on retrolisthesis was studied by using a dry skeleton to mimic the patient image and position. The skeleton was rotated to the point where the femur heads were 50 mm apart. This had no effect on the measured amount of retrolisthesis, which in this case was 5 mm at the L2 level and 0 mm at L5. This is consistent with the physics of distortion, since as all the vertebral levels were rotated while the phantom was turned, the relative rotation angles at the L2-L3 motion segment remained the same. In this study, both radiographs were placed on the illuminator at the same time. This made possible the selection of the appropriate George's line for the assessment of −Z translation. In the rare instance that marked intersegmental rotation was present, mimicking a retrolisthesis, the most anterior George's line was used for the assessment. Since the lateral lumbar portion of the lateral full spine radiograph is taken at a focal film distance of 80 in. this lessens the amount of angular distortion (6° vs. 12°) from what is measured in a 14 × 17 radiograph taken at 40 in. The number of lumbar adjustments performed between examinations averaged 7.97 with a range from 1 to 15.

TABLE 1. The interexaminer reliability of the measurement for retrolisthesis across three observers (A, B and C) and intraexaminer reliability with the same observer (A and A′)

Observers	Pearson's coefficient (r)*	Standard error of estimate (mm)	95% Confidence intervals (mm)	Range (mm)
A and B	0.74	0.82	1.60	1.0–6.5
A and C	0.79	0.72	1.41	1.0–6.5
B and C	0.83	0.67	1.32	2.0–6.5
A and A′	0.90	0.53	1.04	1.0–6.5

*$p < .001$

Fergusen's sacral base angle was drawn and recorded (Figure 3). All angle measurements were made with a commercially available 6-in protractor. Degree measurements were rounded to the nearest 0.5°. The sacral base angle has been previously shown to have a highly

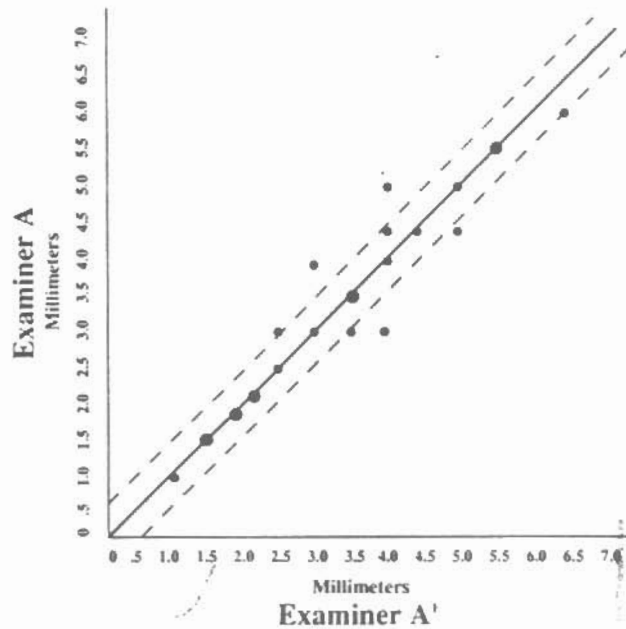

Figure 2. This graph demonstrates the regression line for the correlation coefficient of intraexaminer reliability. The dashed line represents the standard error of the measurement.

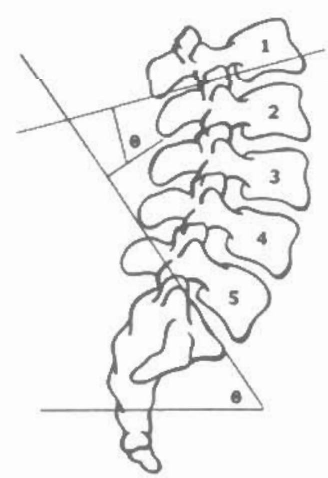

Figure 3. The method used for measuring the lumbar lordosis angle and the sacral base angle.

significant interobserver reliability coefficient (9). No control group was analyzed for the sacral base angle measurement or any of the other variables listed since they are all global postural analyses: this makes control measurements on the same patient impossible. The lumbar lordosis was calculated from L1 to S1 using Cobb's method (18) and was rounded to the nearest 0.5°. Vertebral body end-plate lines extending posterior had perpendicular lines drawn to them, which intersected and formed the lordosis angle (Figure 3). In a large case study (19), significant differences between examiners measuring the lumbar lordotic angle was not found.

The cervical sagittal curve was measured from C2 to C7 and from C1 to C7 (Figure 4). The vertebral body end-plate lines were constructed by drawing a line perpendicular to George's line. The angle was rounded to the nearest 0.5°. Both films were placed on the radiographic viewer at the same time to make it easier to determine similar anatomic points.

Inter- and intraexaminer reliability with standard errors of estimate and 95% confidence intervals was calculated for the measured cervical lordosis (C1-C7) (Table 2) (Figure 5).

When a scoliosis was present on the AP film, as it was in 18 of the 49 cases reviewed, Cobb's angle was measured. As per Cobb's method, the same vertebrae were chosen to construct the angle on both the pre- and post-films (Figure 6). This was possible since both radiographs were on the viewer at the same time. The intraobserver agreement of Cobb's angle has been found to be good (average error 1.9°) (20).

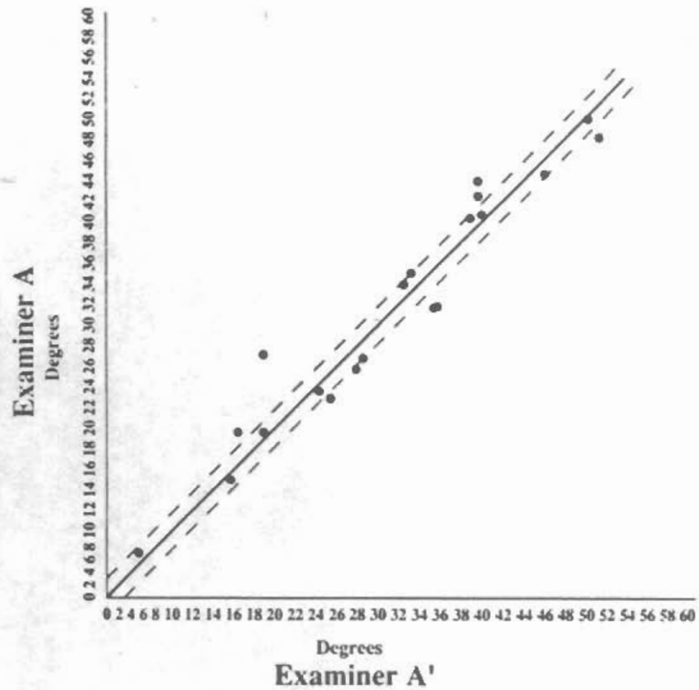

Figure 5. This graph demonstrates the regression line for the correlation coefficient of intraexaminer reliability for the cervical lordosis measurement (C1-C7). The dashed line represents the standard error of the measurement.

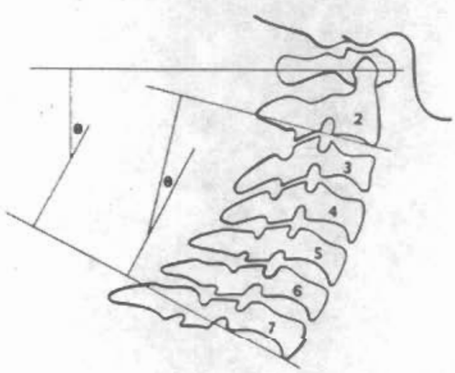

Figure 4. The method used for measuring the cervical lordosis from C2 to C7 and from C1 to C7.

TABLE 2. The interexaminer reliability for the cervical lordosis measurement (C1–C7) across three observers (A, B and C) and intraexaminer reliability with the same observer (A and A′)

Observers	Pearson's coefficient $(r)^*$	Standard error of estimate (°)	95% Confidence intervals (°)	Range (°)
A and B	0.89	4.98	9.76	6.5–50.5
A and C	0.96	3.45	6.76	6.5–50.5
B and C	0.94	4.04	7.91	10.0–49.0
A and A′	0.97	2.88	5.64	5.5–51.0

$^*p < .001$.

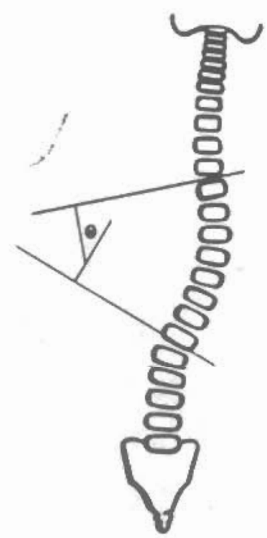

Figure 6. The method of Cobb is used for calculating the scoliosis angle.

The posture of the shoulder girdle was quantitatively analyzed by constructing a line which represented the horizontal configuration of both scapulae. Two similar anatomic points, representing overlapping trabecular patterns along the spine of the scapula, were chosen and a line drawn between the two points, which then interesected a horizontal grid line (Figure 7). It was assumed that the grid line represented a horizontal level. Since the range of angular displacement is quite small in this area, the examiner was requested to estimate the angle to the nearest 0.25°. The higher of the two scapulae was recorded with either an R or L. No inter- or intraexaminer reliability was tested for this measurement.

RESULTS

A total of 49 cases were included in this study. One case was excluded due to difficulties in identifying anatomic landmarks for all the measurement variables analyzed. Radiographically, there were 49 anteroposterior pre-full spine views, 49 anteroposterior post-full spine views, 49 lateral pre-full spine views and 49 lateral post-full spine views. The mean age for this group of patients was 44 yr (SD = 20 yr). Gender distribution was 31 females (63%) and 18 males (37%). The symptomatic profile of the patients was categorized and simplified. Low back pain was the most common complaint, occurring in 79% of the population. Fifty-three percent of the patients had symptoms attributable to either the mid-back or neck. Referral pain into either the shoulder or upper and/or lower extremity was noted in 64%. Forty-seven percent of the cases had symptoms categorized as other (viscerosomatic, organic). This category included headache, constipation, nervousness, dysmenorrhea and shortness of breath.

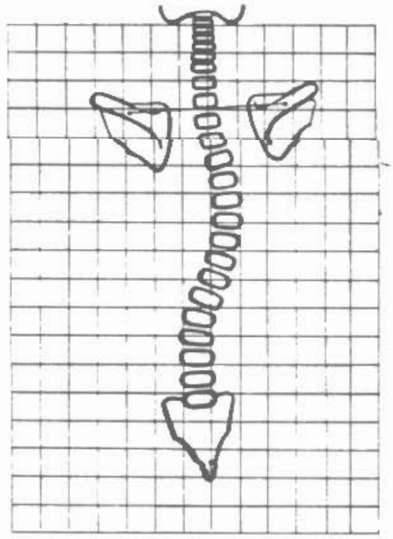

Figure 7. The method used for calculating the angle between both scapulae for assessment of posture of the shoulder girdle.

Lateral Film Measurements

Several measurements were obtained from the lateral full spine films in both the pre and comparative studies. The summary results demonstrated a mean sacral base angle of 37.7° (range 11°-62°, SD 8.9°), a mean lumbar curve angle of 59.4° (range 26°-83.5°, SD 10.4), and a mean of 2.7 mm of retrolisthesis (range 0–7 mm, SD 1.6 mm) of the segments examined. The control group for retrolisthesis demonstrated a mean of 2.3 mm of displacement. The mean age of the controls was 36 yr (SD 14 yr) and the groups were similar in terms of their symptomatic profiles. The cervical lordotic curve (C1-C7) presented with a mean angle of 33.8° (range 5°-65.5°, SD 9.4°). The cervical lordotic curve (C2-C7) presented with a mean angle of 6.1° (range −17°-53°, SD 11.4°) (Table 3).

A paired *t*-test was used to compare the means between the pre and post groups. For retrolisthesis the average value preadjustment was 3.15 mm (SEM = 0.257 mm). The mean value after treatment was 2.03 mm ($p < .001$) (SEM = 0.203 mm). The mean percent change in retrolisthesis was −34%. No statistically significant change was observed in the control group. Other measurements on the lateral films, including the sacral base angle, lumbar curve, cervical curve (C1-C7) and cervical curve (C2-C7), showed no significant changes pre and posttreatment. Table 4 shows the numerical values of the pre and comparative lateral film measurements.

TABLE 3. A summary of lateral full spine measurements with the pre and post values combined

Measurement	Mean	Range	SD
Sacral base angle	37.7	11–62	8.9
Lumbar curve angle	59.4	26–83.5	10.4
Retrolisthesis (mm)	2.7	0–7	1.6
Cervical lordosis			
C1–C7	33.8	5–65.5	9.4
C2–C7	6.1	−17–53	11.4

TABLE 4. Pre and comparative lateral film measurements

Measurement	*n*	Mean (pre)	Mean (post)	*p*
Retrolisthesis (mm)	45	3.15	2.03	< 001
Sacral base angle	48	37.73	38.11	571
Lumbar lordosis	44	58.94	59.80	512
Cervical lordosis				
C1–C7	48	32.77	33.89	.386
C2–C7	48	7.09	7.15	952

AP Film Measurements

Similar to the lateral views, postural evaluations were made and the following summary findings were obtained. The amount of shoulder unleveling averaged 2.3° (range 0°-9.0°, SD 1.7°, $n = 42$). Seven cases were excluded due to difficulty in identifying radiographic landmarks, artifacts and/or poor diagnostic quality in this region of the radiograph. Cobb's scoliosis angle averaged 9.4° (range 0°-54.5°, SD 10.1°) (Table 5). Eighteen pre and post sets of films were evaluated for scoliosis. No statistically significant change was observed with Cobb's angle. Evaluation of shoulder unleveling did not show significant changes following treatment. Table 6 demonstrates the numerical values for the pre and comparative AP film measurements.

DISCUSSION

No significant change was noted in the cervical lordosis upon examination of the initial and comparative radiographs. This contrasts with the findings of Leach (11) who showed significant posttreatment changes, in the magnitude of 2.22°-4.55°. Because Leach's study did not document the reliability of the measurement used, and because the examiner was not blinded to the pre- or post-films, his results may be suspect.

Two measures were used for the cervical curve measurement in an effort to obtain more accuracy. Farfan (21) has alluded to the inaccuracy of measuring the lumbar lordosis with one angle. Similar to the lumbar spine, the upper cervical region can show an apparent increase in the cervical lordosis in the presence of a kyphotic neck posture. This happens when only C1 is used for the upper measurement vertebra.

The average number of cervical or upper thoracic adjustments delivered between the initial and comparative radiographs was 6.5. All subjects retrieved were used regardless of the level of the spine adjusted. This also contrasts with the study by Leach (11), where only subjects that were adjusted at spinal levels theoretically suspected of influencing the hypolordosis were analyzed. Future research on the effect of chiropractic adjustments on the cervical lordosis should address such issues as type and frequency of treatment, and the use of adjunctive procedures such as a cervical pillow and/or cervical traction. It may be found that some manipulative procedures reduce the hypolordosis while others have little effect, or even possibly a reverse effect.

TABLE 5. Summary of AP full spine measurements with pre and post values combined

Measurements	Mean	Range	SD
Unlevel shoulder	2.3	0–9	1.7
Cobb's scoliosis	9.4	0–54.5	10.1

TABLE 6. Pre and comparative AP film measurements

Measurement	n	Mean (pre)	Mean (post)	p
Cobb's angle	18	10.72	8.08	.479
Shoulder angle	42	2.63	2.18	.244

Lumbar Spine Angles

No changes were observed in Fergusen's sacral base angle. Future work which attempts to address a therapeutic effect on the sacral base angle should use subjects who have abnormal (outside the common range) sacral base angles at the onset of treatment.

The lumbar lordotic angle was measured using Cobb's method. This procedure uses perpendicular lines intersecting lines parallel to the end-plates of L1 and S1. The normal range for the lumbar lordotic angle is large (43°-70°) (22). This large range, as similarly found with the sacral base angle, makes it difficult to interpret therapeutic effects of treatment unless the initial values fall outside the normal range. No pre/comparative changes with the lumbar curve were noted in this investigation.

In a report by Roberts et al. (23), it was concluded that lumbar manipulation had no effect on static radiological parameters. There are a number of differences between their study and the one currently being presented. The type of manipulation performed was a bilateral lumbar roll of a nonspecific nature. The procedure was employed three times over a 3-wk period by a medically trained manipulator. The maneuver was not directed at dysfunctioning motion segments, as has been promoted by Cassidy et al. (24). No analysis was made for retrolisthesis, and reliability studies were not performed for the measurements employed. This makes rather suspect the researchers' hypothesis that manipulation has no effect on static radiological parameters of the lumbar spine.

Eighteen out of the 49 patients retrieved had measurable scoliosis angles (> 5°). This group included primarily adult scoliotics. A statistically significant change between the pretreatment and comparative measurements was not seen. On average, 7.97 adjustments were administered between examinations. Future research in this area, especially with adolescent scoliosis individuals, is needed to determine if there is a role for chiropractic adjustments in the rehabilitation of this condition. At this time, chiropractic can offer no documented cure for idiopathic scoliosis. A word of caution is given in regard to the validity of Cobb's angle for the measurement of scoliosis. Since minor changes in the attitude of the end vertebrae will show marked effects in the curve magnitude, a comparison of the actual curve arcs being examined is needed to supplement the measurement.

An analysis was attempted to determine pretreatment and comparative postural changes of the shoulder girdle by using an angle formed between the two scapulae. No significant changes or trends were noted with the scapular angle. Additionally, the validity of the use of this angle as well as the observer reliability of the measurement have yet to be determined.

The results of this study appear to indicate a reduction of retrolisthesis following +Z translatory adjustments to the −Z displaced motion segment. Smith (25) was one of the first researchers to document that the posterior displacement of the fifth lumbar was an important and frequent cause of low back pain. Retrolisthesis is seen with rotational injury to the lumbar spine as well as instability associated with spinal degeneration (26, 27). Other researchers, including Hadley (28), and Kirkaldy-Willis (29) have shown that retrolisthesis is commonly associated with disc degeneration of the lumbar spine. There is controversy with respect to the role of disc degeneration and its relation to retrolisthesis. Rothman et al. (30) have claimed that retrolisthesis is caused by disc degeneration, while Teplick et al. (31) have alluded to the finding that the posterior displacement is seen in the absence of degenerative joint disease. It is unknown whether disc degeneration especially with moderate disc narrowing is responsible for the retrolisthesis, or whether the reverse sequelae may apply.

Certainly, in this investigation there were many individuals with measurable amounts of retrolisthesis without disc narrowing. The retrolisthesis may be caused by, or result from, disc injury which eventually leads to disc thinning and other signs of degeneration. The work of Henson et al. (32) supports this hypothesis. He analyzed posteriorly displaced segments above spondylolisthesis with discography and found pathological changes occurring in the intervertebral disc without pronounced narrowing. Retrolisthesis in combination with spondylolisthesis was not analyzed in this investigation. Epstein et al. (33) has documented the effects of retrolisthesis on the lateral recess and subsequent nerve root entrapment. Multiplanar computerized tomography has been used in the evaluation of the neural foramina in patients with retrolisthesis (30, 31). Foraminal stenosis is a frequent concomitant finding in subjects with retrolisthesis (30, 31). Retrolisthesis may complicate the clinical picture of patients with central or lateral stenosis due to degenerative joint disease, by further occluding the central canal or lateral recess. In cases where disc protrusion is evident, retrolisthesis may limit the amount of space the nerve root has in accommodating to the disc bulge. On average, 7.97 adjustments were performed on the subjects before the comparative radiograph was taken.

The intraexaminer reliability for the measurement was excellent (Pearson's $r = 0.90$, $p < .001$), standard error of the estimate = 0.53 mm). The measurement appears to be a reproducible and sufficiently precise method for analyzing retrolisthesis of the lumbar spine as viewed on static radiographs, and will provide a vehicle for further prospective investigations in this area.

CONCLUSION

The results of this study suggest that while under chiropractic care, translatory adjustments of retrolisthesis in the lumbar spine as evaluated by standard plane film radiography can reduce the displaced functional spinal unit by approximately 34%. When compared to a control group, a similar change failed to occur. Further, the method of mensuration used in this analysis was found to have excellent inter- and intraexaminer reliability. At the 95% confidence interval the standard error of the measurement for intraexaminer reliability was 1.06 mm. This error in precision should not be construed as having applicability to the mean difference of the pre/post sample (1.12 mm). The proper error that should be ascribed to the mean difference is the standard error of the mean, which was small (0.20–0.26 mm). The error in the precision of a measurement, if somewhat large, actually strengthens the conclusion that an effect took place, provided that effect is statistically significant. Error occurs at random and can be thought of as a cloud of uncertainty around any given value. When measuring tools are very precise, much smaller effects are needed in order for them to be statistically significant, provided the n is sufficiently large. Conversely when measuring tools are relatively imprecise, they may fail to capture small differences between samples.

Studies are needed to determine the validity of both small and large displacements on the lateral recess, the central canal, and their associated soft tissue structures. While the mean change in retrolisthesis seen in this experiment was small (1.12 mm), this did represent a 34% reduction in the displacement. If future studies use preselected samples with larger initial displacements (> 5 mm), then a 34% reduction could be more clinically significant. Even though a relative change in position has been demonstrated, what significance does this convey to the patient and or his/her management? Further research needs to address the relationship between relative change in osseus positions as demonstrated in this study and standard means of evaluating patient outcomes. Further research is also needed to demonstrate anatomical relationships and how these changes may relate to normal function. These investigations should also address the issue of control for adjustive evaluations. The control group for the retrolisthesis measurement was 23 patients, with measurements taken from nonadjusted segments that demonstrated retrolisthesis ($n = 18$) and pure controls with no adjustments ($n = 5$). The assumption is made that a segment two levels away from the adjusted segment is not affected by the adjustive procedure. The assumption remains untested and may be suspect. Although, significant changes were noted on the pre/post evaluation of retrolisthesis, no changes were observed for pre/post adjustment on the cervical lordosis, lumbar lordosis, sacral base angle, scoliosis angle or the scapular angle. The value of these measures are suspect based on the results of this study. The number of adjustments between evaluations was eight (range 1–15).

The reliability of the measurement of cervical lordosis was found to be excellent. However, at the 95% confidence interval, the intraexaminer error could be as high as 6°. Obviously any small mean differences in the cervical curve angle, if they in fact occurred at all, could easily be hidden by the large imprecision of the measurement.

It is incumbent upon us to demonstrate how X-rays benefit case management. Future work in the area of radiographic evaluation and its relationship to spinal adjustments should be a high priority for the chiropractic profession.

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REFERENCES

1. Reinert OC. An analytical survey of structural aberrations observed in static radiographic examinations among acute low back cases. J Manipulative Physiol Ther 1988; 11:24–30.
2. Phillips RB. The use of X-rays in spinal manipulative therapy. In: Haldeman S. ed. Modern developments in the principles and practice of chiropractic. New York: Appleton Century Crofts, 1980: 189–208.
3. Banks SD. The use of spinographic parameters in the differential diagnosis of lumbar facet and disc syndromes. J Manipulative Physiol Ther 1982; 6:113–16.
4. Torgerson WR, Dotter WE. Comparative roentgenographic study of the asymptomatic and symptomatic lumbar spine. J Bone Joint Surg [Am] 1976; 58:850–3.
5. Carrick FR. Treatment of pathomechanics of the lumbar spine by manipulation. J Manipulative Physiol Ther 1981; 4:173–8.
6. Carrick FR. Cervical radiculopathy: the diagnosis and treatment of pathomechanics in the cervical spine. J Manipulative Physiol Ther 1983; 6:129–37.
7. Shippel AH, Robinson GK. Radiological and magnetic resonance imaging of cervical spine instability. J Manipulative Physiol Ther 1987; 10:316–22.
8. Phillips RB, Frymoyer JW, MacPherson BV, Newburg AH. Low back pain: a radiographic enigma. J Manipulative Physiol Ther 1986; 9:183–7.
9. Herbst RW, ed. Gonstead chiropractic science and art. Mt. Horeb, WI: Sci-Chi Publications, 1968.
10. Cox JM. Low back pain: mechanism, diagnosis and treatment. Baltimore: Williams & Wilkins, 1985; 298–326.
11. Leach RA. An evaluation of the effect of chiropractic manipulative therapy on hypolordosis of the cervical spine. J Manipulative Physiol Ther 1983; 6:17–23.
12. Aspegren DD, Cox JM. Correction of progressive idiopathic scoliosis utilizing neuromuscular stimulation and manipulation: a case report. J Manipulative Physiol Ther 1987; 10:147–56.
13. Barge FA. Scoliosis. Davenport, IA: Baldwine Printing, 1982.
14. Thornton RE. Cervical kyphosis. J Clin Chiro 1971; (Archive Ed. 1):192–3.
15. Field TJ, Buehler MT. Improvements in chiropractic full spine radiography. J Manipulative Physiol Ther 1981; 4:21–6.
16. Denslow JS, Chace JA, Gutensohn OR, Kumm MG. Methods in taking and interpreting weight-bearing X-ray films. In: Peterson B, ed. Postural balance and imbalance. Newark, OH: American Academy of Osteopathy, 1983: 144–51.
17. Rhudy TR, Sandefur MR, Burk JM. Interexaminer/intertechnique reliability in spinal subluxation assessment: a multifactorial approach. Am J Chiro Med 1988; 1:111–4.
18. Hansson T, Bigos S, Beecher F, Wortley M. The lumbar lordosis in acute and chronic low back pain. Spine 1985; 10:154–5.
19. Fernand R, Fox DE. Evaluation of lumbar lordosis: a prospective and retrospective study. Spine 1985; 10:799–803.
20. Goldberg MS, Poitras B, Mayo NE, Labelle H, Bourassa R, Cloutier R. Observer variation in assessing spinal curvature and skeletal development in adolescent idiopathic scoliosis. Spine 1988; 13:1371–7.
21. Farfan HF. Mechanical disorders of the low back. Philadelphia: Lea and Febiger, 1973: 14.
22. Barge FH, Woodruff DD, Otto LF. The lumbar lordotic angle. In: Suh CH, ed. Biomechanics conference on the spine. Boulder, CO: University of Colorado Department of Mechanical Engineering, 1983: 277–88.
23. Roberts GM, Roberts EE, Lloyd KN, Burke MS, Evans DP. Lumbar spinal manipulation on trial. Part 2. Radiological assessment. Rheumatol Rehabil 1978; 17:54–9.
24. Cassidy JD, Kirkaldy-Willis WH, McGregor M. Spinal manipulation for the treatment of chronic low back and leg pain: an observational study. In: Buerger AA, Greenman PE, eds. Empirical approaches to the validation of spinal manipulation. Springfield, IL: Charles C Thomas, 1985: 119–50.
25. Smith A. Posterior displacement of the fifth lumbar vertebra. J Bone Joint Surg [Am] 1934; 16:877–88.

26. Knutsson F. The instability associated with disc degeneration in the lumbar spine. Acta Radiol 1944; 25:593.
27. Morgan ED, King T. Primary instability of lumbar vertebrae as a common cause of low back pain. J Bone Joint Surg [Br] 1957; 39:6.
28. Hadley LA. Anatomicoroentgenographic studies of the spine. 5th ed. Springfield, IL: Charles C Thomas, 1981: 390–3.
29. Kirkaldy-Willis WH. The site and nature of the lesion. In: Kirkaldy-Willis WH, ed. Managing low back pain. New York: Churchill-Livingstone, 1983: 98.
30. Rothman SLG, Glenn WV, Kerver CW. Multiplanar CT in the evaluation of degenerative spondylolisthesis. A review of 150 cases. Computerized Radiol 1985; 9:223–32.
31. Teplick JG, Laffey PA, Berman A, Haskin ME. Diagnosis and evaluation of spondylolisthesis and/or spondylosis on axial CT. AJNR 1986; 7:479–91.
32. Henson J, McCall IW, O'Brien JP. Disc damage above a spondylolisthesis. Br J Radiol 1987; 60:69–72.
33. Epstein JA, Epstein BS, Lavine LS, Carras R, Rosenthal AD, Sumner P. Sciatica caused by nerve root entrapment in the lateral recess: the superior facet syndrome. J Neurosurg 1972; 36:584–9.