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Original Articles

Effect of Unilateral Spinal Adjustments on Goniometrically-Assessed Cervical Lateral-Flexion End-Range Asymmetries in Otherwise Asymptomatic Subjects

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ABSTRACT

A triple blinded, mutiple-measure, experimental protocol was employed in order to investigate the effectiveness of unilateral cervical adjustments on goniometrically assessed cervical lateral-flexion asymmetries. On pretest, subjects selected for the experiments exhibited mean left-right lateral-flexion differences of approximately 14°. In subjects which either received no intervention, or had been subjected only to preliminary palpatory and set-up procedures but no thrust, asymmetry magnitudes were found to be unchanged on goniometric posttesting done 30–45 min later. However, in subjects which received lower cervical adjustments performed on the side of most restricted end-range, there was a dramatic reduction in asymmetry magnitudes. Furthermore, the adjustment procedure used in this investigation appeared to be relatively side-specific, since adjustments, when delivered to the less restricted side, were only marginally effective in ameliorating the asymmetries. Potential clinical relevance as well as the possible structural or physiological mechanisms responsible for the results obtained in the study are discussed. (J Manipulative Physiol Ther 12; 6:419–427)

Key Indexing Terms: Cervical Spine, Motion, Chiropractic.

INTRODUCTION

Proper empirical evaluation of the effectiveness of the chiropractic adjustment or any other therapeutic intervention ultimately requires:

1. That a valid, reliable measure of dysfunction be available, and:
2. That the pathophysiological condition under investigation be stable enough to allow statistical comparisons to be made both prior to and, again, following sham (control) or real therapeutic intervention.

Even though a number of measures (e.g., galvanic skin response, neurocalimetry, motion and static palpation, leg length inequality, X-ray marking systems, and thermography) have been put forth as possible tools for the detection of "subluxations", results obtained from scientific investigations carried out under controlled, blinded, clinical or laboratory conditions have raised serious questions concerning the reliability and/or validity of these various procedures (1–12). Recently, however, Tucci et al. (13), Zackman et al. (14) and Schmid et al. (15), have resurrected the notion that *simple range of motion assessment* (goniometry) might provide a valid and reasonably reliable method of evaluating at least one parameter of vertebral function. We are aware of only two published reports (16, 17) in which cervical range of motion was used as an outcome measure to empirically evaluate the effects of spinal manipulation. Unfortunately, even though the results of both investigations seemed to indicate manipulation-induced changes in over-all range of motion, either no control group was included in the study (17) or care was not taken to blind the individual responsible for goniometric assessment from treatment categories (16). In any case, the results, while not altogether unequivocal, were compelling, and therefore were considered to be worth pursuing under more carefully controlled

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experimental circumstances. Although over-all range of motion is known to be rather variable across subjects (18), it seemed reasonable to adopt, at least for the time being, the view that *asymmetry* of range of motion within subjects might represent a potentially meaningful parameter of vertebral motion dysfunction.

METHODS AND MATERIALS

Goniometric Assessment

In order to begin this series of investigations, it was necessary to first establish the statistical validity of range of motion asymmetry, in this case, with respect to cervical lateral-flexion end-range. Chiropractic students ranging from 22–41 years of age and about evenly divided with respect to gender were selected as subjects, and a hand-held pendulum goniometer was used for range of motion assessment. The goniometric assessor stood behind the seated subject and placed the goniometer on top of the subjects head. Starting from the neutral position, five left and five right passive alternating lateral-flexion end-range measures were taken on each subject within about 1 min. In order to control for operator bias, the goniometer dial was kept facing away from the individual in charge of manipulating the subject's head and all measurements were read and recorded by another experimenter, referred to hereafter as the recorder, who stood in front of the subject.

Subjects were instructed to remain seated and relaxed, and were retested approximately 30–45 min later. This multiple-measure protocol allowed for statistical (t-test) comparisons to be made between left and right sides (asymmetry validity), as well as between the first and second test measures (asymmetry stability).

Results obtained from these experiments demonstrated that mean left vs. right lateral-flexion end-range differences of 8° or more were always statistically significant at the $p < 0.001$ level or better, whereas asymmetries of 5° or less often did not meet 0.05 levels of significance (Figure 1).

Additionally, goniometric measurements performed on the same subjects 30 min later yielded very high test-retest correlation coefficients ($r = 0.94$) for mean left (pre) vs. mean left (post) and mean right (pre) vs. mean right (post) comparisons, ($n = 66$). This, of course, was reflected in the stability of group mean asymmetries over the 30 min time period (Figure 2).

Treatment Categories

Given that the before-mentioned criteria of validity and test-retest reliability had been satisfactorily established, it was now possible to examine whether or not cervical adjustments were capable of ameliorating lateral-flexion asymmetries. Only subjects exhibiting left vs. right end-range differences of 8° or more were selected for this phase of the investigation, and a seated cervical adjustment technique (19) was chosen as the therapeutic modality. The experiment consisted of four groups of subjects:

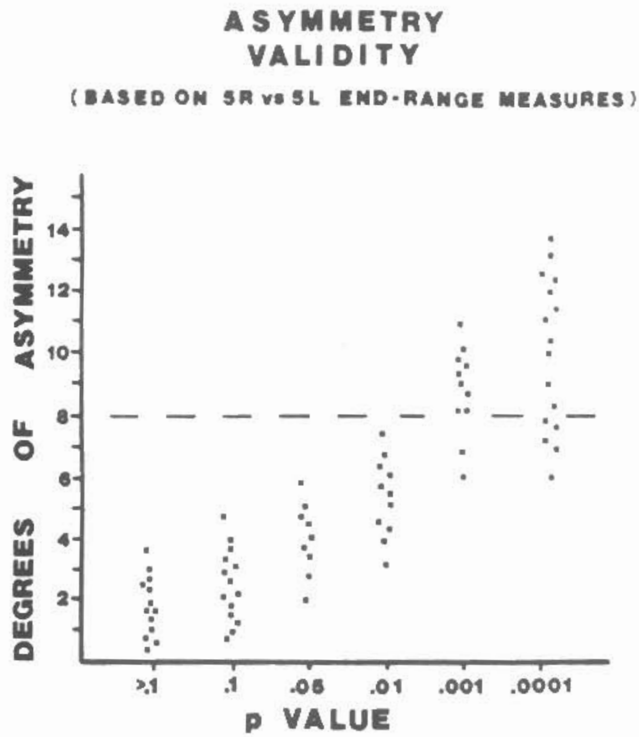

Figure 1. Statistical comparisons (t-test) between left vs. right goni9ometric measures taken on 67 subjects exhibiting varying degrees of cervical lateral-flexion end-range asymmetry. Mean left-right differences of 8° or more were always significant at $p < 0.001$ levels or better, whereas differences of 5° or less often did not meet 0.05 levels of significance, and therefore could not be construed to represent statistically valid asymmetries.

1. *No Rx:* those receiving no intervention between pre- and postgoniometric testing ($n = 9$).
2. *Set-up, no thrust:* Those subjected to all preliminary palpatory and set-up procedures only ($n = 9$).
3. *Adjusted most-restricted side:* those in which the adjustment was delivered only to the side of greatest end-range restriction ($n = 14$).
4. *Adjusted least-restricted side:* those in which the adjustment was delivered only to the side of least end-range restriction, i.e., side of of greatest end-range ($n = 11$).

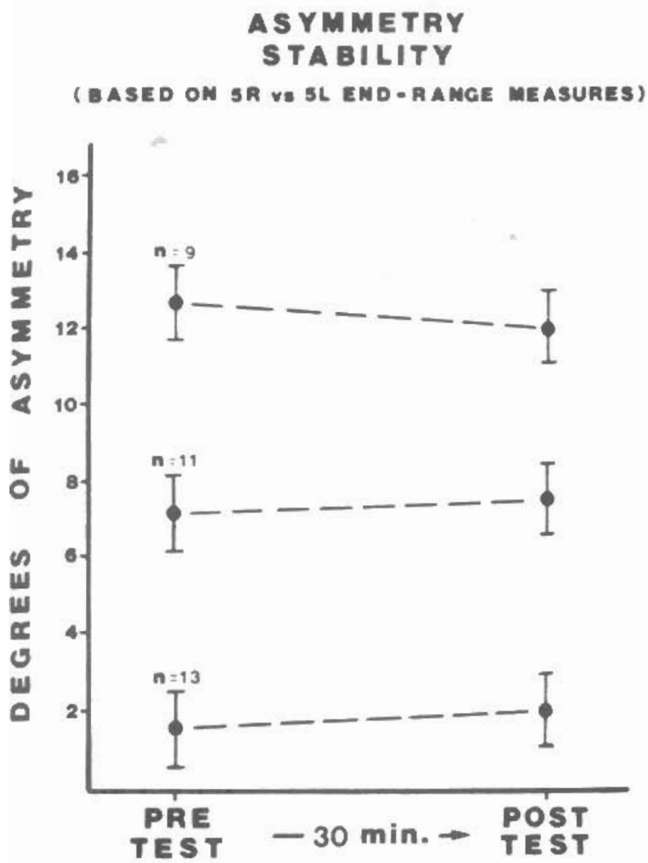

Figure 2. Test-retest stabilities of goniometrically determined cervical lateral-flexion end-range asymmetries (mean ± SEM) in three groups of subjects over a 30 min time period. Mean left (pretest) vs. mean left (posttest) and mean right (pretest vs. mean right (posttest) comparisons (data not shown) yielded very high correlation coefficients ($r = 0.94$). This, of course, was reflected in the stabilities of group mean asymmetries.

Experimental Protocol

Following pregoniometric testing and subject selection (on any given day one could expect approximately 10-15% of the student population to exhibit a cervical lateral-flexion end-range asymmetry of 8° or more), the recorder assigned subjects to the four treatment groups. The experimenter in charge of manipulating the subject's head was blinded, as before, from the actual goniometric readings, as well as from subject treatment categories. The practitioner responsible for performing the adjustments was also blinded from pretest goniometric findings, and was told by the recorder which side to adjust. For set-up no thrust controls, the adjuster was instructed to direct his palpatory procedure to the most restricted side and was allowed to take the subject "to tension," (see set-up procedure, below), but was then instructed to release the subject at the last instant, just prior to delivering the thrust. Postgoniometric assessment was performed within 30–45 min following treatments, during which time subjects were instructed to remain seated and quiet. Data for the four groups were collected from three separate experiments and pooled for final analysis.

Spinal Manipulative Procedure

Cervical adjustments, whether delivered to the most-restricted or least-restricted side, were performed in the following manner.

Set-up: The adjusting doctor, standing behind and slightly toward the side to be adjusted, placed his stabilization hand on top of the subjects head, and the head was flexed slightly in order to effect separation of the spinous processes. The tip of the index finger of the contact hand was then placed on the end of the spinous process of the cervical vertebrae below the one to be adjusted. Then the contact finger was moved up so that it fit under and slightly lateral to the spinous of the vertebra being adjusted.

The thumb of the contact hand was then placed on the ramus of the jaw so that an arch was formed between the thumb and index finger (spinous contact). Using the stabilization hand, the head was then brought back into a more relaxed position, and the stabilization hand was then placed along the posterior-lateral portion of the cervical spine opposite the side to be adjusted. The chin was then elevated slightly and the head flexed laterally about 10–15° and rotated slightly towards the side to be adjusted. The slack was then reduced (taken to tension) by applying pressure on the spinous process with the contact finger.

Thrust: The thrust (high velocity) was made with the contact hand. The function of the stabilization hand was merely to guide the motion of the head as the thrust was applied, and not to pull the head back across the contact finger. The thrust, which was made almost entirely with a rotational motion of the wrist and forearm, acted to lift the spinous process upward while also moving it anteriorly and medially. Depending on the palpatory "impression" of the adjusting doctor, all subjects received adjustments directed at C5, C6, C7 or T1 vertebral segments on the side indicated by the recorder. It should be noted, however, that this procedure almost always yielded multiple "audibles," suggesting multiple segment involvement. In a few (five) cases, again based on palpatory impressions, an upper cervical (C1, C2, or C3) adjustment was also performed on the same side

TABLE 1. Pre-post cervical lateral-flexion goniometric data obtained from four groups of subjects; those which received no intervention between pre- and post goniometric testing (NO RX), those subjected to all preliminary palpatory and "set-up" procedures only (SET-UP NO THRUST), those in which the cervical adjustment was delivered only to the side of least end-range restriction (ADJ.-LEAST RESTR. SIDE) and those which received adjustments only on the side of greatest end-range restriction (ADJ.-MOST RESTR. SIDE).

Pre-test cervical lateral flexion endrange measures (degrees)					Posttest cervical lateral flexion endrange measures (degrees)					
Left side (raw scores)	X̄	Right side (raw scores)	X̄	L/R△	Left side (raw scores)	X̄	Right side (raw scores)	X̄	L/R△	% prepost△
44 45 40 42 45	(43)	32 34 35 33 34	(34)	9	43 42 40 45 44	(43)	32 35 36 32 30	(33)	10	+10
50 52 50 54 48	(51)	38 40 36 35 38	(37)	14	52 48 50 50 52	(50)	38 36 35 39 35	(37)	13	−7
45 48 46 48 44	(45)	64 60 58 63 60	(61)	16	46 44 42 48 46	(45)	58 64 60 62 60	(61)	16	+7
38 36 36 34 38	(36)	44 42 42 46 45	(44)	8	40 38 58 56 39	(48)	52 48 48 56 45	(48)	10	+25
47 49 48 51 49	(49)	34 38 38 36 36	(36)	13	50 43 42 48 51	(47)	38 38 37 38 37	(38)	9	−31
65 66 62 66 66	(65)	50 48 48 48 52	(49)	16	62 64 66 63 61	(63)	46 48 52 52 46	(49)	14	−13
36 35 35 35 35	(35)	53 56 56 52 54	(54)	19	30 36 35 34 31	(33)	55 56 55 53 55	(55)	22	+16
45 43 43 46 42	(44)	50 51 51 53 54	(52)	8	47 43 48 44 46	(46)	58 58 57 56 59	(58)	12	+50
60 58 56 58 56	(58)	47 45 45 46 46	(46)	12	59 53 57 57 60	(57)	46 45 42 46 43	(44)	13	+8
NO RX (n = 9)				12.7 ± 1.2					13.2 ± 1.3	
35 31 33 33 32	(33)	44 43 49 46 48	(46)	13	29 33 36 34 32	(32)	47 50 50 44 44	(47)	15	+15
42 44 45 42 45	(44)	51 50 51 54 53	(52)	8	42 38 41 44 41	(41)	53 52 54 53 53	(53)	12	+50
53 53 51 54 53	(53)	44 44 45 43 44	(44)	9	56 56 58 58 55	(56)	39 35 42 38 40	(39)	17	+90
44 46 45 45 45	(45)	54 51 52 57 54	(54)	9	46 47 47 48 48	(47)	54 58 50 53 55	(54)	7	−22
34 35 38 36 36	(36)	55 55 56 55 55	(55)	19	38 37 36 39 38	(38)	53 53 54 53 53	(53)	15	−21
63 60 62 61 62	(62)	52 49 48 49 46	(49)	13	62 68 69 66 66	(66)	41 44 46 45 49	(45)	21	+62
48 49 49 49 50	(49)	58 57 57 57 57	(57)	8	47 49 48 49 50	(49)	53 61 58 58 57	(58)	9	+13
62 56 58 60 59	(59)	40 38 41 44 42	(41)	18	53 52 56 58 59	(56)	37 38 38 39 38	(38)	18	0
57 54 54 51 54	(54)	30 35 34 33 31	(33)	21	55 54 54 54 54	(54)	27 31 33 36 30	(31)	23	+10
SET-UP NO THRUST (n = 9)				13.1 ± 1.7					15.2 ± 1.8[a]	
40 41 41 42 41	(41)	49 48 51 52 50	(50)	9	46 48 44 42 45	(45)	47 47 50 15 54	(50)	5	−44
36 36 38 40 38	(38)	54 53 54 55 54	(54)	16	38 42 40 44 46	(42)	53 56 51 54 54	(54)	12	−25
29 33 30 27 30	(30)	50 50 47 52 51	(50)	20	33 35 35 32 34	(34)	50 56 50 52 52	(52)	18	−10
48 47 48 47 47	(47)	63 63 65 65 65	(64)	17	50 49 48 51 53	(51)	65 61 62 64 63	(63)	12	−30
58 58 60 60 54	(58)	46 48 48 44 44	(46)	12	55 55 56 56 56	(56)	46 46 50 51 50	(49)	7	−40
50 46 45 47 47	(47)	64 64 65 64 64	(64)	17	49 52 53 48 56	(52)	66 60 60 67 63	(63)	11	−35
46 45 46 46 45	(46)	57 60 61 65 62	(61)	15	58 58 60 54 58	(58)	52 55 48 48 49	(50)	8	−47
40 46 46 39 43	(43)	33 35 34 37 31	(34)	9	47 47 47 44 44	(46)	37 34 34 33 33	(34)	12	+33
61 61 65 64 67	(64)	45 45 44 46 45	(45)	19	67 69 69 65 67	(67)	50 54 55 51 53	(53)	14	−26
50 50 50 51 51	(50)	57 60 63 60 60	(60)	10	49 51 49 55 53	(52)	61 61 62 16 62	(62)	10	0
46 45 48 40 45	(45)	56 58 61 54 59	(58)	13	46 50 42 46 45	(46)	58 59 55 55 51	(55)	9	−30
ADJ. - LEAST RESTR. SIDE (n = 11)				14.3 ± 1.1					10.7 ± 1.2[b]	
57 62 61 60 63	(61)	48 48 48 46 48	(48)	13	60 62 62 61 63	(62)	63 60 60 57 60	(60)	2	−85
42 42 43 42 42	(42)	60 63 59 57 61	(60)	18	63 60 58 57 59	(59)	58 59 60 59 59	(59)	0	−100
66 68 68 64 66	(66)	50 54 49 48 52	(51)	15	61 68 68 66 67	(66)	63 69 70 67 66	(67)	1	−93
37 40 40 40 44	(40)	46 48 44 49 50	(48)	8	43 52 48 46 47	(47)	49 50 50 48 48	(49)	2	−75
56 53 58 56 56	(56)	44 46 44 46 45	(45)	11	55 55 55 54 55	(55)	54 56 41 58 58	(55)	0	−100
68 70 68 74 69	(70)	51 56 55 59 55	(55)	15	65 71 70 72 69	(69)	57 56 59 56 60	(58)	9	−40
38 38 40 36 38	(38)	46 54 47 53 50	(50)	12	48 48 50 52 49	(49)	48 50 52 56 53	(52)	3	−75
48 50 50 52 51	(50)	68 68 68 68 65	(67)	17	58 58 57 58 58	(58)	60 60 60 58 58	(59)	1	−94
37 33 32 34 33	(34)	41 43 45 45 45	(44)	10	40 41 47 46 45	(44)	43 43 43 44 45	(44)	0	−100
40 41 40 42 40	(41)	60 59 60 60 60	(60)	19	59 55 56 58 55	(57)	57 63 63 63 58	(61)	4	−79
34 33 32 34 33	(33)	40 43 38 46 42	(42)	9	38 40 40 39 41	(40)	41 41 42 40 41	(41)	1	−89
43 40 43 41 42	(42)	53 53 54 51 51	(52)	10	52 50 56 56 54	(54)	50 56 56 52 54	(54)	0	−100
49 49 46 45 47	(47)	68 68 67 67 67	(67)	20	66 67 71 70 71	(69)	65 63 69 69 67	(67)	2	−90
34 38 37 36 38	(37)	50 54 51 55 53	(53)	16	50 56 56 53 53	(54)	52 54 51 56 56	(54)	0	−100
ADJ. - MOST RESTR. SIDE (n = 14)				13.8 ± 1.05					1.8 ± .65[c]	

[a] $p > 0.1$ when compared to NO RX controls.
[b] $p < 0.025$ when compared to NO RX controls.
[c] $p < 0.001$ when compared to NO RX controls; $p < 0.001$ when compared to ADJ. - LEAST RESTR. SIDE.

as for the lower cervical one. However, results obtained on posttest goniometric assessment indicated that the effects of adjustment on lateral-flexion asymmetry when both adjustments were performed were indistinguishable from those in which only the lower cervical adjustment was done. Although it is impossible, retrospectively, to be certain whether upper cervical adjustments were at all responsible for any improvement in lateral-flexion end-range observed in this investigation (in no case did subjects receive only an upper cervical adjustment), it seems unlikely that mobilization of the upper cervical spine contributed significantly to range of motion improvement in neutral lateral-flexion, since in that plane, most of the motion occurs through movement in the lower regions of the cervical spine.

Goniometric Data Analysis

Following treatments, the goniometric assessor re-entered the laboratory and subjects were re-examined (posttest) in a manner identical to that employed for pretesting. Mean left vs. mean right end-range difference (in degrees) was first determined for pretest and posttest measures taken on each subject. Statistical comparisons between the four treatment groups were made by expressing the differences in the magnitudes of lateral-flexion end-range asymmetries for individual subjects following treatment as percent pre-post change, and then comparing the treatment group percentage data by simple t-test analysis.

RESULTS

All pre-and posttest goniometric data are shown in Table 1. Results of the experiment were as follows. On pretest, No Rx, Set-up no thrust, Adjusted-least restricted side, and Adjusted-most restricted side groups exhibited population mean asymmetries (± SEM) of 12.7 ± 1.2, 13.1 ± 1.7, 14.3 ± 1.1, and 13.8 ± 1.05 °, respectively. As anticipated, No Rx and Set-up no thrust groups exhibited mean asymmetries on posttest which were virtually identical to those on pretest (13.2 ± 1.3 and 15.2 ± 1.8 °, respectively). However, for the group of subjects which received cervical adjustments delivered to the side of greatest end-range restriction (Adjusted-most restricted side) the mean asymmetry was found on posttest to have been greatly reduced, to a value of 1.8 ± 0.65°. On the other hand, although adjustments delivered to the less restricted side (Adjustments-least restricted side) did cause a significant ($p < 0.025$) decrease in the mean asymmetry exhibited by that group (i.e., from 14.3 + 1.1 to 10.7 + 1.2°), the magnitude of the effect was marginal compared to the dramatic reduction of asymmetry observed when adjustments were delivered to the most restricted side (Figure 3).

It is important to point out that the adjustment-induced reduction of left-right asymmetry was due, almost entirely, to improved range of motion on the originally most-restricted side, and due very little to any significant decrease in end-range on the originally less-restricted side. Although this is readily apparent upon perusal of the data in Table 1, it was felt that a statistical examination of the relative effect of adjustments on most-restricted vs. least-restricted sides was in order. As can be seen in Figure 4, the mean postadjustment increases in end-range (degrees) on the originally most restricted side for subjects who received adjustments either on the most-restricted or least-restricted sides were 12.5 ± 1.3 and 4.3 ± 1.0°, respectively. On the other hand, for both groups, adjustments induced only slight, and nonsignificant ($p > 0.1$) decreases in end-range on the originally least-restricted side (−0.86 ± 0.66 and −0.73 ± 1.2 °).

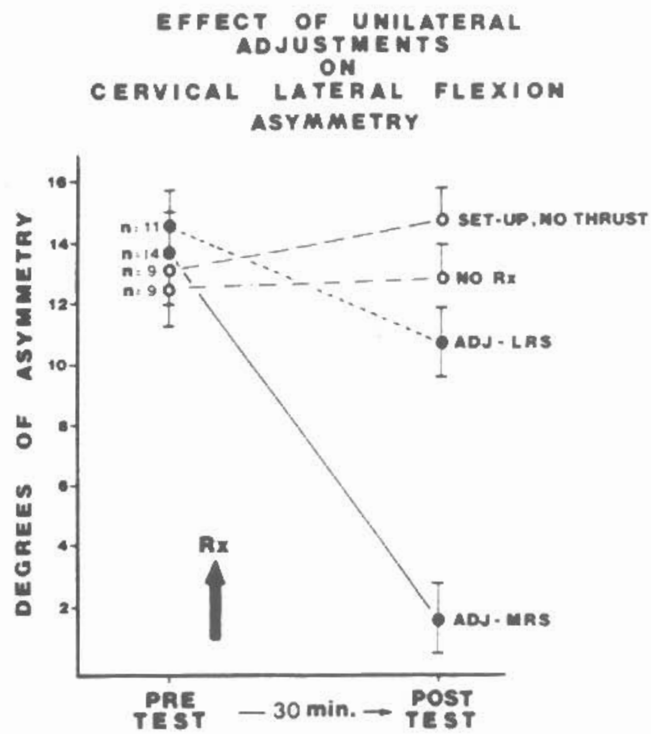

Figure 3. Graphic representation of the data shown in Table 1. On pretest, all treatment groups exhibited mean cervical lateral-flexion end-range asymmetries ± SEM) of approximately 14°. As anticipated, No Rx and Set-up no thrust groups had not changed significantly on posttest 30 min later. Even though adjustments delivered to the side of least end-range restriction (ADJ-LRS) caused a significant ($p < 0.025$) reduction in the mean asymmetry exhibited by that group, the magnitude of the effect was only marginal compared to the dramatic amelioration of asymmetry brought about when adjustments were delivered to the side of greatest end-range restriction (ADJ-MRS).

DISCUSSION

The significance of the goniometric assessment protocol (outcome measure) used in these experiments cannot be emphasized enough. As pointed out earlier (in the introduction) quite a bit of investigative time

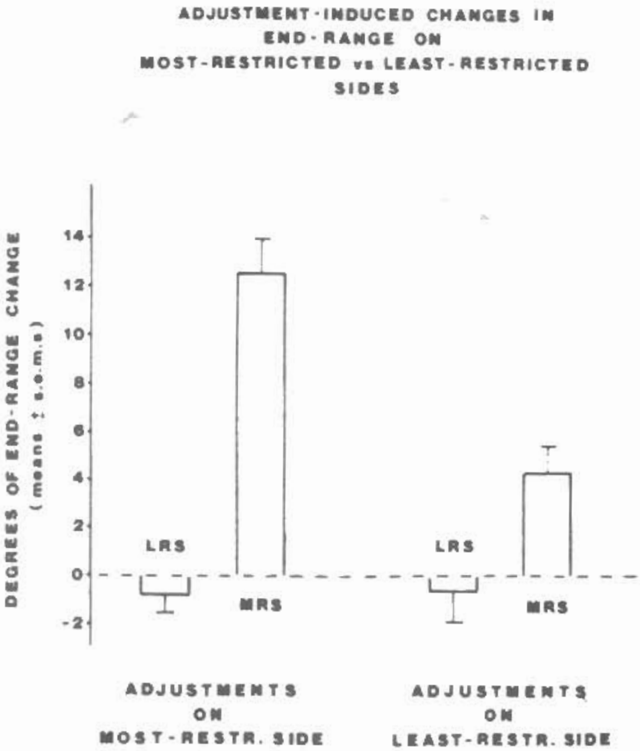

Figure 4. Graphic depiction of the data shown in Table 1, demonstrating that the amelioration of cervical lateral-flexion end-range asymmetry was due almost entirely to improved range-of-motion on the most-restricted side (MRS) and due only slightly to a decrease in range-of-motion on the least-restricted side (LRS). Again, as in Figure 3, it can be seen that adjustments delivered to the most-restricted side were much more effective in improving end-range than when adjustments were performed on the least-restricted side.

and energy has been spent in attempts to determine the validities and/or reliabilities of a variety of instruments or measurement protocols (some objective, some subjective) with respect to certain presumed or proposed indices of vertebral "subluxation." Considering the marginal to poor results obtained thus far with respect to the establishment of a reliable, much less valid, method for assessing at least one parameter indicative of some aspect of vertebral dysfunction, we consider our choice of cervical lateral-flexion end-range asymmetry to be quite fortuitous, indeed. In fact it is the high degree of validity and test-retest reliability determined in advance for the goniometric procedure used in these experiments that made the investigation possible.

Additionally, a few comments regarding the "blinded" nature of the experimental protocol employed for this investigation are also in order. First of all, during the course of the study, it had been determined that the subjects themselves were unable to reliably identify their own side of most restricted end-range, and therefore could not be certain whether they had received adjustments on the most-or least-restricted side. Secondly, the adjusting doctor also was not given the goniometric "listings," but was told by the recorder which side to adjust on. Finally, the experimenter in charge of manipulating the subject's head not only could not see the actual goniometric readings, but was blinded from all treatment group assignments as well. Therefore, at least for the comparison between Adjustment-most restricted side vs. Adjustment-least restricted side groups, this study may very well represent the first triple-blind (subject, therapist, outcome assessor) investigation of the effect of spinal manipulative therapy (20, 21), in this case, with respect to the amelioration of cervical lateral-flexion end-range asymmetry. Further studies employing this basic methodology are in progress to compare the initial effectiveness as well as the longevity of this and other manipulative techniques or physiotherapeutic procedures with respect to cervical motion characteristics.

The results of this investigation could not, of course, provide information concerning the exact mechanism(s) which might have been operative in mediating the new adjustment-induced effects on cervical motion observed in these experiments. However, a number of theories have been put forth which could feasibly explain the results obtained by our study. These various hypotheses fall into two general categories; a) those based on structural considerations, and b) those based on neuromuscular reflexogenic considerations.

Structural Hypotheses

The meniscus entrapment theory (22–27)

This theory maintains that the apex of fatty meniscoids get trapped between the articular surfaces, becoming lodged in a recess created between the articular cartilages, thereby restricting motion. Manipulation (gapping of the joint) could act to dislodge and displace the meniscoid, thus returning full motion to the joint.

The meniscus extrapment theory (27)

This theory advances the notion that with flexion, the articular processes subluxate and the exposed articular surfaces are covered by a meniscoid. Upon extension, the meniscoid, instead of re-entering the joint space, deviates and comes into contact with the opposite articular process and then deflects into the adjacent sub-capsular pocket. As the size of the displaced meniscoid increases (like a space-occupying lesion) the meniscoid buckles and causes capsular distension, thus restricting motion. Gapping of the joint by manipulation would have the effect of displacing the meniscoid from the sub-capsular pocket into its normal position, thus returning full motion to the joint.

Intradiscal nuclear displacement (27–31)

This theory supposes that upon flexion, a fragment of nuclear pulposus material extrudes into a radial fissure and lodges between the superficial laminae of the annulus fibrosis. Upon attempted extension, the central nucleus can adjust to the redistribution of forces. However, the satellite portion, trapped like a bubble, would act to restrict compression and therefore motion along that plane. Manipulation could act to force the fragment circumferentially into another plane, or back along the radial fissure into its normal position amongst the central disc material, thus returning normal motion to the joint.

Reflex Hypotheses

Reflexes involving capsular afferents (32, 33)

This theory recognizes the fact that vertebral joints (particularly cervical ones) are rather heavily innervated by Type I and II afferents. Type I afferents appear to possess Ruffini type low threshold, slow adapting receptors which exhibit tonic discharge even when no movement is occurring (static position detectors). Type II afferents, which possess rapidly adapting Pacinian-like or Golgi tendon organ-like receptors appear to discharge only when movement is occurring (movement or acceleration detectors). In the spinal cord, these afferents make polysynaptic connections primarily with gamma-motor neurons, thus acting to alter the sensitivity of muscle spindles and therefore muscle tone. Changes in capsular pressure brought about by normal loads and stresses on the joint thus create, through complex afferent-efferent reflex activites, changes in muscle tone which act to stabilize certain joints while allowing full motion in others. Changes in capsular integrity or pressure changes brought about through misalignment, structural anomalies (meniscoid entrapment), or irritation (edema), could create aberent afferent signals which, through normal reflex responses, lead to inappropriate increases in muscle tone, thus restricting motion. Gapping of the joint by manipulation to create a barrage of capsular afferent discharge, may cause reflex-induced decreases in muscle tone, thus allowing for increased joint movement.

Muscle tendon organ receptors

It has been well established that Golgi tendon organ receptors, through their type Ib afferents, make disynaptic inhibitory reflex connections with alpha motor neurons. Thus, one could envision that stretch of muscle tendons by manipulation could cause decreases in muscle tone, thus allowing for greater range of motion in segments regionally related to those paraspinal muscle groups.

Obviously, much more work will need to be done, including animal studies, postmortem investigations and more sensitive radiographic analyses (e.g., magnetic resonance or fluoroscopy) before elucidation of the exact mechanism(s) which mediate the effects of spinal manipulative therapy is possible. Until then, however, much information can still be obtained which could be of great value to the practitioner, even in lieu of precise description(s) of the mechanisms involved.

Meanwhile, for those who might be tempted to extrapolate our findings to the clinical setting, a note of caution is in order. First of all, the subjects selected for this study were pain-free, and therefore may not typify the average patient under spinal manipulative care. Also the results of this study, although rather dramatic, do not provide information concerning the longevity of the effects (beyond the 30–45 min time period investigated). On the other hand, the asymmetries exhibited by the subjects selected for this investigation were close to the 15° orthopedic benchmark (34, 35) for cervical motion dysfunction (7 of the 14 subjects in the Adjustment-most restricted side group exhibited initial asymmetries of 15° or greater). According to these guidelines, a 15° reduction of cervical lateral-flexion represents a 1–2% whole body physical impairment. Therefore, we believe this study represents an experimental design-template upon which to begin to investigate the biomechanical effects of various manipulative and physiotherapeutic procedures, and that ultimately results obtained from such investigations will provide new information applicable to the successful amelioration of various forms of clinically relevant dysfunctional or pathophysiological states involving aberrant cervical spinal motion. On that point, it is reasonable to assume, for instance, that asymmetries of cervical motion need not necessarily manifest themselves most clearly, or at all, along neutral axes. Also, it is widely recognized that lateral-flexion and rotational end-ranges differ considerably with varying degrees of anterior-posterior flexion-extension, and that this is due to changes in the proportions of biomechanical forces exerted at different cervical segmental levels. Therefore, it would seem that proper analysis of cervical spinal motion would include end-range assessment of both lateral-flexion as well as rotation at different degrees of anterior-posterior flexion. At this writing, development of a goniometric device and protocol for an accurate, reliable, multiplaner analysis of passive cervical motion end-range characteristics is in progress in our laboratory (21).

It is hoped that the multiple-measure, multiple-group, blinded experimental protocol reported here, coupled with a more comprehensive analysis of cervical motion capability, will ultimately help delineate those manipulative techniques or physiotherapeutic procedures which are particularly well-suited for various specific forms of cervical motion dysfunction.

CONCLUSION

The results of this triple blind, and therefore, we believe, highly interpretable, investigation suggest that in otherwise asymptomatic subjects exhibiting cervical lateral-flexion asymmetries, unilateral cervical adjustments performed on the side of greatest end-range restriction are capable of dramatically ameliorating the asymmetries, at least over the 30–45 min time period investigated. Furthermore, the "effectiveness" of the adjustment technique used in this study appears to be relatively side specific, since the same adjustments delivered to the side opposite to that of greatest end-range restriction were only marginally effective in reducing asymmetry magnitudes.

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