

Original Articles

Time Course Considerations for the Effects of Unilateral Lower Cervical Adjustments with Respect to the Amelioration of Cervical Lateral-Flexion Passive End-Range Asymmetry

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ABSTRACT

The initial effectiveness as well as the temporal stability of the effect of cervical spinal manipulation with respect to the amelioration of goniometrically verified cervical lateral-flexion passive end-range asymmetry was examined. Responses of two groups of pain-free subjects were compared: a) those exhibiting end-range asymmetries of greater than 10° who, in addition, had suffered previous neck trauma, and; b) those who happened to exhibit end-range asymmetries of greater than 10° but who had no history of prior neck trauma. All subjects received a single lower cervical adjustment delivered to the side of most-restricted end-range, and goniometric reassessments were performed 30 min, 4 hr, and 48 hr following the adjustment. A dramatic amelioration of asymmetry was observed in both groups at 30 min and 4 hr postmanipulation. Furthermore, the magnitudes of these short-term effects were similar for the two groups. However, by 24 hours, a difference in the temporal responses of the groups had become readily apparent. By 48 hours, the difference was even more striking; whereas 14 of 16 of the subjects with no

previous neck trauma continued to exhibit asymmetries of less than 10° (mean \pm SEM = 3.8 \pm 1.0°), 12 of the 16 subjects with previous neck trauma had regained asymmetries of greater than 10° (mean \pm SEM = 11.4 \pm 1.7°). These results indicate that among asymptomatic (pain-free) individuals, the mere presence of passive end-range asymmetry as well as the magnitude of the short-term ameliorative effect of cervical manipulation do not distinguish these two categories of subjects. On the other hand, over long periods of time following manipulation, there appears to be a tendency of individuals who have suffered previous neck trauma to reestablish their aberrant cervical motion characteristics. The possible clinical relevance of these findings is discussed, and suggestions put forth regarding the definition of chronic cervical motion dysfunction. Possible mechanisms (e.g., spinal learning) which may be responsible for this condition are also addressed. (*J Manipulative Physiol Ther* 1990; 13:297-304).

Key Indexing Terms: Cervical Spine, Motion, Chiropractic.

INTRODUCTION

Results of previous investigations carried out in this laboratory (1) have demonstrated a rather robust, albeit short-term, side-specific effect of unilateral lower cervical adjustments with respect to the amelioration of

goniometrically verified cervical lateral-flexion passive end-range asymmetry. Although adjustment-induced effects observed in those earlier experiments were highly consistent based on goniometric reassessment performed 30 min posttreatment, no information was obtained with regard to the stability of the effect over longer periods of time following cervical manipulation.

Subsequent to our original report, results of pilot investigations (unpublished) had suggested that certain subjects, in particular those who had suffered previous neck trauma (e.g., whiplash) from 1-8 years earlier, tended to regain close to their original degrees of end-range asymmetry within 24 to 48 hr following treatment. Therefore, in the study reported here, the initial

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effectiveness as well as the temporal stabilities of the effects of lower cervical adjustments were directly compared in two groups of subjects: a) those exhibiting cervical lateral-flexion passive end-range asymmetries of 10° or greater who, in addition, had an established history of previous neck trauma and frequent episodic neck stiffness, and: b) those who happened to exhibit passive end-range asymmetries of 10° or greater on the day of the experiment, but who reported no previous neck trauma and only occasional episodes of noticeable neck stiffness.

MATERIALS AND METHODS

Subject Selection Criteria

Chiropractic college students, about evenly divided with respect to gender, and ranging from 23 to 48 yr of age, were selected as subjects for the investigation. The experiment included the following two groups of subjects:

1. Those individuals who had suffered previous neck trauma (e.g., whiplash, sports related injuries, falls, etc.) from 1–8 years earlier, and who had complained of frequent episodes (3–5 days per wk) of neck “stiffness” subsequent to the original injury. Of 23 such subjects who volunteered for the experiment, 16 were found to exhibit goniometrically-confirmed cervical lateral-flexion passive end-range asymmetries of 10° or greater on day 1 and were, therefore, included in the study. None of these subjects reported neck pain, although some (7 of 16) did report the sensation of “neck stiffness” on day 1 of the experiment.
2. Those individuals with no previous history of neck trauma, and who reported only occasional episodes (less than 1 per wk) of mild to moderate neck “stiffness.” Thirty-seven such subjects had to be screened goniometrically in order to obtain a balanced group of 16 who happened, on day 1 of the experiment, to exhibit cervical lateral-flexion passive end-range asymmetries of 10° or greater. As with the other group, none of these subjects reported significant neck pain, although some (4 of 16) did report the sensation of neck “stiffness.”

Goniometric Assessment

Cervical lateral-flexion passive end-range measurements were performed using a Cybex EDI 320 Electronic Goniometer. The sensor of the goniometer was placed on top of the subject's head in neutral position,

and the subject was instructed to close his/her eyes and relax. Subjects were also instructed to hold on to the bottom of the chair seat in order to stabilize their shoulders during the taking of the measures. Two left and two right passive, alternating, lateral-flexion end-range measures were then taken on each subject. The two measures were averaged and the left vs. right differences rounded to the nearest degree. In order to avoid operator bias, the digital read-out unit (connected to the sensor by a 5 foot cord) was kept out of view of the experimenter in charge of passively manipulating the subject's head, and all measures were read and recorded by another experimenter. The experimenter in charge of passive manipulation was also kept blinded with respect to subject category throughout the course of the experiment. Subjects were instructed to return to the laboratory for goniometric reevaluation at 30 min, 4 hr, 24 hr, and 48 hr following cervical manipulation. All subjects were instructed not to receive any additional cervical manipulation or other forms of physiotherapy for the 48 hr following the experimental adjustment, and not to engage in any “unusual” activities (exercise, etc.) involving their necks, but to otherwise carry on their normal daily activities.

Spinal Manipulative Procedures

Within approximately 15 min following initial goniometric screening and subject selection (based on the demonstration of a left-right passive end-range difference of 10° or greater), all subjects received a single lower cervical adjustment (vertebral segments C6, C7 or T1) delivered to the goniometrically-determined side of most-restricted end-range. Cervical adjustments identical to the type employed for previous studies (1) were performed in the following manner.

The adjusting doctor, standing behind and slightly toward the side to be adjusted, placed his stabilization hand on top of the subject's 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 posterolateral 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.

The thrust was made (high velocity) with 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, each subject received a single adjustment directed at C6, C7 or T1 vertebral segment on the side of goniometrically verified most-restricted end-range. It should be noted, however, that this procedure almost always yielded multiple "audibles," suggesting multiple segment involvement.

Goniometric Data Analysis

Statistical comparisons of the magnitudes of left vs. right end-range difference (asymmetry magnitudes) at different times following treatment were performed using a 2 × 5 repeated measures Analysis of Variance.

RESULTS

A brief review of results obtained from previous investigations carried out in this laboratory is included here for background purposes. For more details, see Nansel et al. (1). A graphic depiction of the outcomes of this earlier study is illustrated in Figure 1.

The results of this earlier experiment had indicated that in otherwise asymptomatic individuals exhibiting significant cervical lateral-flexion passive end-range asymmetries, a single lower cervical adjustment, when delivered to the most-restricted side of end-range, was capable of consistently and markedly ameliorating the magnitude of asymmetry, at least over the relatively short time period investigated (i.e., 30 min). Therefore, the same adjustment procedure was used for the experiment described in this report.

Goniometric data obtained from this subsequent experiment are shown in Table 1. Cervical lateral-flexion passive end-range asymmetries prior to cervical manipulation ranged in magnitude from 10° (minimum selection criteria) to 19°. Although the mean asymmetry magnitude for the group of subjects with a history of neck trauma was slightly higher than for the other group on pretest, this difference did not meet .05 levels of statistical significance.

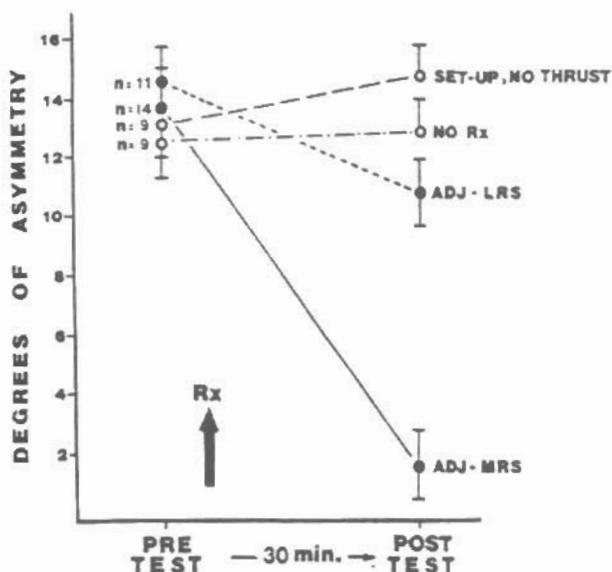


Figure 1. Pre-post passive cervical lateral-flexion goniometric data (expressed as degrees of left-right asymmetry) obtained from four groups of subjects: those which received no intervention between pre- and post-goniometric testing (NO RX), those subjected to all preliminary palpatory and "set-up" procedures only (SET UP NO THRUST), those in which the cervical adjustment was delivered only to the side of least restricted range-of-motion (ADJ-LRS) and those which received an adjustment only on the side of most restricted range-of-motion (ADJ-MRS). On pretest, all four treatment groups exhibited mean cervical lateral-flexion end-range asymmetries of approximately 14°. As anticipated, NO RX and SET-UP NO THRUST groups had not changed significantly on post-test 30 minutes later. Even though adjustments delivered to the side of least restricted end-range caused a significant $p < .025$ reduction in the mean asymmetry exhibited by that group, the magnitude of this effect was only marginal compared to the dramatic amelioration of asymmetry brought about when adjustments were delivered to the side of most restricted end-range. (Reprinted, by permission, from the *Journal of Manipulative and Physiological Therapeutics* 1989; 12(6):419-433.)

As in earlier experiments, cervical adjustments were found to induce significant amelioration of asymmetry magnitudes in both groups of subjects at 30 min post-treatment. This effect was maintained at 4 hours in both groups as well. Even though there appeared to be a slight tendency for this short-term effect to be less marked in some of the subjects with previous neck trauma, this difference did not meet .05 levels of significance for statistical comparisons between the groups.

By 24 hours posttreatment, however, a clear and statistically significant difference in the temporal responses of the two groups had become readily apparent. This was due to the fact that whereas none of the 16 subjects without previous neck trauma exhibited end-range asymmetries of greater than 10° by that time, 7 of the 16 subjects with a history of prior neck trauma

TABLE 1. Cervical lateral-flexion passive end-range goniometric data obtained 15 min. prior to, and again 30 min, 4 hours, 24 hours, and 48 hours following cervical adjustments.

	Pretest: Cervical Lateral Flexion Passive End Range Measures (degrees) -15 min			Posttests: Cervical Lateral Flexion Passive End Range Measures (degrees)											
	L	R	L/RΔ	30 min			4 hrs			24 hrs			48 hrs		
				L	R	L/RΔ	L	R	L/RΔ	L	R	L/RΔ	L	R	L/RΔ
No previous neck trauma (n = 16)	48	38	10	48	48	0	51	53	2	49	47	2	49	52	3
	50	32	18	49	51	2	51	50	1	50	49	1	48	49	1
	52	38	14	51	49	2	53	50	3	53	50	3	52	47	5
	37	49	12	49	49	0	47	48	1	47	47	0	48	48	0
	31	49	18	48	48	0	47	48	1	48	49	1	46	49	3
	37	52	15	51	52	1	53	52	1	52	43	1	53	53	0
	53	41	12	53	54	1	54	54	0	52	51	1	51	52	1
	54	41	13	52	54	2	53	54	1	56	55	1	57	56	1
	48	59	11	57	58	1	58	58	0	56	57	1	55	58	3
	46	29	17	47	42	5	46	42	4	40	48	8	39	46	7
	51	63	12	57	60	3	57	62	5	61	54	7	60	48	12*
	38	28	10	39	39	0	38	37	1	39	37	2	39	37	2
	38	20	18	37	34	3	38	35	3	37	33	5	37	35	2
	49	36	13	47	47	0	48	48	0	45	45	0	47	44	3
	55	41	14	56	53	3	57	55	2	56	50	6	58	45	13*
	32	43	11	41	44	3	41	43	2	44	42	2	42	47	5
Group (± SEM) Means			13.7 ± .68			1.6 ± .38			1.7 ± .43			2.5 ± .63			3.8 ± 1.0
Previous neck trauma (n = 16)	36	48	12	39	47	8	40	49	9	36	51	15*	37	51	14*
	53	34	19	52	49	3	51	47	4	52	37	15*	51	35	16*
	24	43	19	41	43	2	35	42	7	30	42	12*	31	44	13*
	41	56	15	55	55	0	55	55	0	53	54	1	53	53	0
	43	27	16	42	41	1	44	39	5	43	26	17*	39	25	14*
	43	28	15	42	37	5	43	39	4	43	37	6	38	34	4
	38	23	15	38	37	1	39	38	1	39	27	12*	38	26	12*
	38	48	10	48	48	0	49	50	1	45	49	4	31	48	17*
	32	43	11	43	44	1	44	44	0	44	43	1	44	44	0
	48	31	17	46	40	6	48	44	4	48	41	7	50	31	19*
	37	48	11	46	47	1	43	48	5	38	47	9	28	46	18*
	33	52	19	49	51	2	36	49	3	38	51	13*	37	52	15*
	35	48	13	44	48	4	45	49	4	39	50	11*	29	47	18*
	43	25	18	42	42	0	41	40	1	41	46	5	43	33	10*
	58	41	17	59	52	7	57	50	7	59	53	6	59	48	11*
	32	48	16	47	48	1	47	48	1	49	49	0	49	48	1
Group (± SEM) Means			15.2 ± .74			2.7 ± .63			3.5 ± .68			8.4 ± 1.3			11.4 ± 1.7

had regained asymmetries of greater than 10° (note asterisks in Table 1).

By 48 hours, the difference between the two groups was even more striking. All but four of the subjects with previous neck trauma had regained asymmetries of greater than 10°, whereas 14 of the subjects without previous neck trauma continued to exhibit asymmetries of less than 10°. In fact, by 48 hours posttreatment, the mean asymmetry magnitude exhibited by the group of subjects with previous neck trauma was no longer significantly different from that exhibited by the group prior to treatment. It is also important to note that for this group, the reestablished motion restriction was, in every case, on the same side as that observed originally, prior to the adjustment. Graphic depiction of individual

subject as well as group goniometric data are illustrated in Figure 2.

DISCUSSION

We feel it is appropriate to address some rather important issues regarding the possible scientific and/or clinical significance of this series of investigations. Our continued employment of this "inductive" approach to the examination of the biomechanical influences of spinal manipulation certainly reflects our enthusiasm for the experimental paradigm, if nothing else. That being the case, we suggest that, at the least, these studies may serve to draw attention to some rather basic, but nevertheless critical, issues encountered equally in both the laboratory and clinical setting.

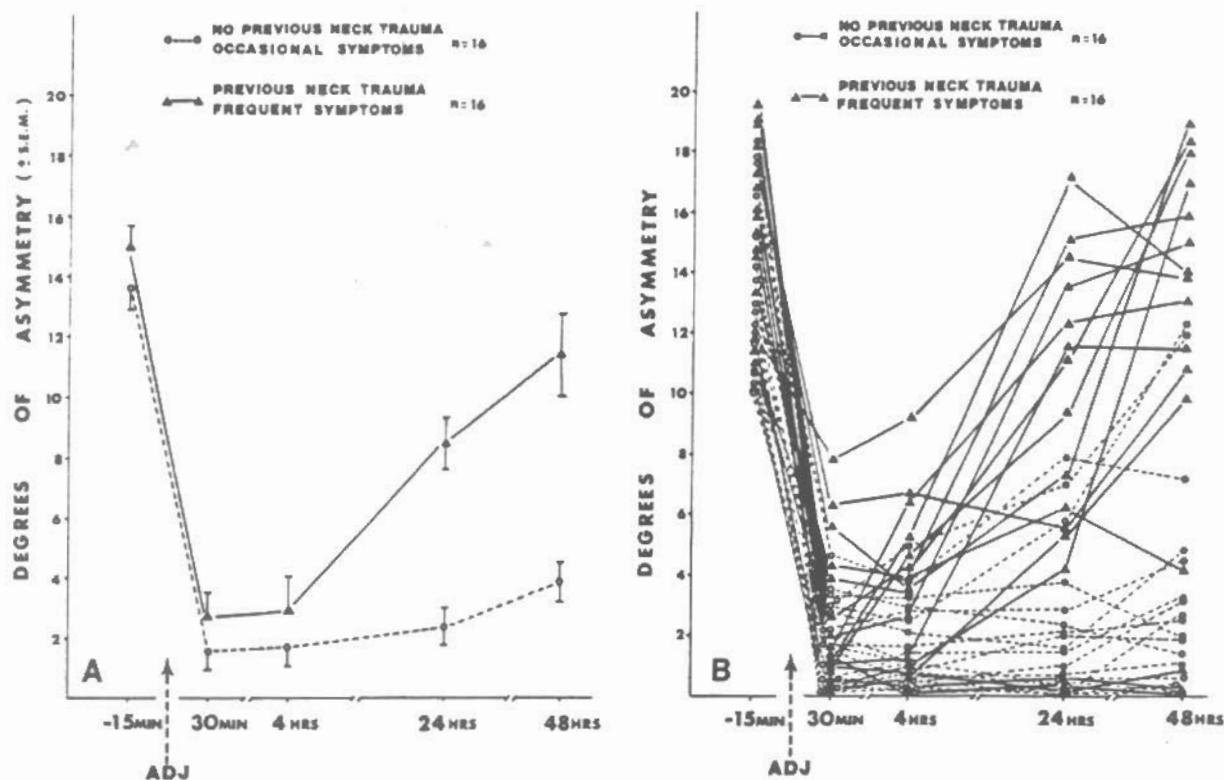


Figure 2. Graphic representation of the group (A) and individual (B) goniometric data from Table 1. Cervical adjustments induced a significant short term amelioration of asymmetry magnitude in both groups of subjects. Although this effect was slightly less robust in the group of subjects with previous neck trauma at 30 min and 4 hours posttreatment (A), this difference did not meet .05 levels of significance. However, by 24 and 48 hours following cervical manipulation, a difference in the response of the two groups of subjects had become readily apparent: most of the subjects with previous histories of neck trauma exhibited a tendency to reestablish close to their original degrees of end-range asymmetry. By 48 hours, 12 out of 16 subjects with prior neck trauma had regained asymmetry magnitudes of 10° or greater, whereas only 2 out of 16 subjects without previous history of neck trauma had regained asymmetries of greater than 10° by that time (A). In fact, by 48 hours following cervical manipulation, the mean asymmetry magnitude of the group of subjects with prior neck trauma was no longer significantly different from that initially exhibited by the group prior to manipulation (A). Individual cervical lateral-flexion passive end-range asymmetries prior to cervical adjustment ranged in magnitude from 10° (minimum selection criterion) to 19° (B).

One of the more important of these considerations is the validity and/or reliability of measures (tests) which are used in an attempt to define and/or distinguish various "physiologic" or "pathophysiologic" states, and, to help evaluate experimental or clinical outcomes. Indeed, it is the use of a reasonably reliable, objective outcome measure (i.e., goniometrically verified cervical lateral-flexion passive end-range asymmetry) which has made this series of investigations at all interpretable (1). Therefore, it may be that experiments such as the ones reported here contribute primarily by providing information which may be useful with respect to experimental design and implementation.

In addition to considerations regarding the validity and reliability of various outcome measures, these investigations also draw attention to some important questions concerning the appropriate definition of "cervical motion dysfunction." It should be kept in mind

that our investigations have thus far been confined to situations in which subjects, although exhibiting significant lateral-flexion asymmetries, have been otherwise asymptomatic (pain-free). Therefore, results obtained from this and previous studies (1) may have little bearing in circumstances in which recent trauma, inflammation and pain are also part of the clinical presentation. On the other hand, it is not unreasonable that states of "aberrant" vertebral motion capability might be viewed as dysfunctional, even when pain and inflammation are no longer (or not yet) part of the clinical picture. This issue, of course, is a much more difficult one to resolve, particularly in light of the fact that rather wide fluctuations in the magnitudes of a variety of biological parameters (asymmetries, if you will) are often found to be important features of "normal" physiologic regulatory processes.

For instance, random goniometric screening of our

student population reveals that on any given day, as many as one out of every three individuals can be expected to exhibit a cervical lateral-flexion passive end-range asymmetry of 10° or greater. We, of course, took advantage of the availability of large numbers of such individuals (subjects) in order to initiate this series of investigations (1). We consider these earlier studies to be important, if only because they demonstrate the feasibility of examining the biomechanical influences of spinal manipulation under controlled (in fact, triple-blinded) laboratory conditions. On the other hand, it is quite possible that the results obtained in those experiments were simply the reflection of a transient, adjustment-induced disruption of otherwise normal oscillating physiologic patterns of asymmetric cervical paraspinal muscle activity. Current disability guidelines notwithstanding (2, 3), absolute magnitudes of passive end-range asymmetry, when considered in isolation, certainly did not distinguish the two groups of subjects examined in the study reported here (i.e., asymmetry magnitudes were as great in subjects who had not suffered previous neck trauma as they were in subjects who had). Therefore, we would seriously question the legitimacy of the term "dysfunctional" if based solely on the mere observation of a passive end-range asymmetry of 15° .

In an attempt to apply our earlier experimental approach to a category of subjects which we felt might be representative of a truly "dysfunctional" status, results from our earlier study did provide useful information concerning the adjustive strategy which would be expected to be effective, at least for the group of control subjects who had not experienced previous neck trauma. Surprisingly, only a few of the subjects with previous neck trauma were found to respond significantly less well insofar as the short-term ameliorative effects of the adjustment were concerned. We expect that on a statistical basis, differences in the short-term responses of the two groups would probably have been more apparent had the experiment involved larger numbers of subjects. In the clinical setting, however, involving individual patients, it appears that neither the mere presence of a 10 – 20° passive end-range asymmetry, nor the effective short-term therapeutic amelioration of it, would provide sufficient information to reliably distinguish between the two potential patient categories of the type examined in this study. Rather, it seems that the factor which most clearly and consistently delineated the differences between these two groups of subjects was instead related to the more long-term natural (or unnatural) history of the goniometric phenomenon (i.e., passive end-range asymmetry mag-

nitude) following its transient adjustment-induced amelioration.

A number of alternative experimental strategies could have been employed in order to examine the natural history of lateral-flexion end-range asymmetry. We could have chosen to simply compare the magnitudes and frequencies of passive end-range asymmetry in the two groups over several weeks. However, in addition to being extremely tedious, this would have required that a large number of chiropractic students forgo any form of spinal manipulation or physiotherapy for an extended period of time. Therefore, this approach was rejected, not for a lack of scientific merit, but because of an obvious lack of feasibility. Our somewhat different approach was still able to objectively reveal a rather strong and reasonably consistent tendency on the part of individuals with histories of neck trauma and frequent episodic neck "stiffness" to reestablish asymmetries that may be indicative of a chronic aberrant pattern of passive end-range asymmetry. It is important to recall that in every case for this group asymmetries were found to reestablish themselves on the same side as that observed prior to manipulation. This is not consistent with the notion that the asymmetries exhibited by this group were due to random physiologic oscillations. Unfortunately, we did not obtain goniometric data for a long enough time period in order to know whether asymmetries would have exhibited more random side relationships if and when they returned in subjects without previous neck trauma. It is interesting to note that of the three such subjects which significant ($> 8^\circ$) return of asymmetry did occur by 48 hours, two were found to have reversed with respect to their side of greatest end-range restriction.

Unfortunately, on the basis of results obtained in this study, it is not possible to offer any definitive conclusions regarding the underlying anatomic or physiologic mechanism(s) responsible for creating what appears to be a tendency of the cervical spine to reestablish a side-specific, asymmetric pattern of passive lateral flexion end-range capability in individuals with previous neck trauma. Nevertheless, we feel somewhat compelled to stick our own cervical spines out just a bit and propose a plausible mechanism and sequence of events which may have conspired to produce the biomechanical state of affairs.

First of all, it has become quite well established that afferent nociceptive signals from injured articular structures are capable of initiating and facilitating certain spinal reflex pathways. These pathways in turn act to increase gamma and/or alpha motor efferent discharge, thus increasing the contractile activity of the

paraspinal musculature, thereby restricting movement across the affected joints. These so called "guarding responses" are thought to represent a protective reflex mechanism designed to prevent further injury to the joint during the processes of inflammation and repair. For a much more comprehensive discussion of this topic, please see the excellent reviews by Wyke (4, 5), Haldeman (6), Korr (7), Kirkaldy-Willis and Cassidy (8), Plum and Posner (9), Roland (10), Farfan (11) and Slosberg (12, 13).

More recently, a number of investigators have provided experimental evidence which suggests that repetitive articular afferent stimulation can, in fact, produce alterations in the thresholds of certain central nervous system reflex pathways. These alterations may far outlast the period of actual afferent stimulation (14-27). Initiation and reinforcement of this type of "spinal learning" or reflex entrainment may depend on the type, intensity, frequency and duration of the original afferent barrage, and would also be expected to be influenced by a whole host of other factors which may act to perpetuate the mechanism over a longer period of time.

It does not seem unreasonable to imagine, then, a situation in which nociceptive input, whether from traumatized articular osseous or soft tissue paraspinal structures, might have facilitated a set of reflex-based guarding responses, most likely asymmetric ones. The associated pain and muscle stiffness may have persisted for several days, weeks, or even longer following the initial injury to the lower cervical spine. Even after pain was no longer present in static neutral position, attempted movement toward the most restricted side of motion might still have been uncomfortable, thus reinforcing additional habitual, asymmetric movement characteristics related to pain avoidance. Of course, recurrent traumatic episodes (e.g., from unguarded movement into the side of end-range restriction), even if only moderate in severity, would reinforce and perpetuate the neuromuscular reflex mechanism. Thus, long after the original injury, this aberrant, asymmetric end-range pattern might have become quite well entrained. In fact, it could very well be that the spinal cord not only would have "learned" this less adaptive, and possibly downright dysfunctional reflex pattern, but would now tend to maintain the preferred pattern, even in response to normal articular afferent input.

Obviously, much more information will need to be obtained in order to establish the validity of this rather simplistic working hypothesis. In the meantime, continued work in our laboratory will attempt to determine whether or not it is possible, in subjects similar to those

examined in the study reported here, to therapeutically re-entrain a more permanent symmetric pattern of cervical end-range capability.

CONCLUSION

The results of this study demonstrate that in subjects with a history of neck trauma and frequent episodic neck stiffness who also exhibit significant cervical lateral-flexion passive end-range asymmetries, a single unilateral lower cervical adjustment delivered to the side of most restricted end-range is capable of reducing the magnitude of asymmetry. For most of these individuals, however, this effect is only transient, as asymmetry magnitudes are found to return to close to pre-treatment values within 48 hours following manipulation. These observations draw attention to the need for long-term temporal assessment of the effects of spinal adjustment, thus allowing for a more comprehensive and appropriate categorization of cervical motion dysfunction.

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