454 Journal of Manipulative and Physiological Therapeutics
Volume 17 • Number 7 • September, 1994
0161-4754/94/1707-0454 $03.00/0 © 1994 JMPT

The Efficacy of Cervical Extension-Compression Traction Combined with Diversified Manipulation and Drop Table Adjustments in the Rehabilitation of Cervical Lordosis: A Pilot Study

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ABSTRACT

Objective: To experimentally investigate the effect of cervical extension-compression traction combined with diversified chiropractic manipulation and drop table adjusting in establishing or increasing cervical lordosis.

Design: Blinded, before and after trial with pre- and postlateral cervical radiographic measurement.

Setting: Primary care private chiropractic clinic in Saugus, MA.

Subjects: A) Control group—convenience sample who had no health care for 10–14 wk, 30 persons. B) Treatment group 1, nonrandomized control trial, 35 persons, whose pre- and postlateral cervical radiographs were taken 10–14 wk apart and whose radiographs clearly depicted C1 through C7. C) Treatment group 2, nonrandomized control trial, 30 persons, whose pre- and postlateral cervical radiographs were taken 10–14 wk apart and whose radiographs clearly depicted C1 through C7.

Interventions: Treatment group 1: diversified spinal manipulation, drop table adjustments and cervical extension-compression traction five times per week for 10–14 wk (12 wk ± 2). Treatment group 2: diversified spinal manipulation and drop table adjustments five times per week for 10–14 wk (12 wk ± 2).

Main Outcome Measures: Anterior head translation millimeters, C2 to C7 absolute rotation angle, angle of C1 to horizontal (atlas plane angle), five relative rotation angles (C2-3, C3-4, C4-5, C5-6, C6-7) and qualitative classification of lordotic configuration.

Results: No statistically significant changes existed between the pre- and posttests for the control group except in the C6–7 relative rotation angle. In the treatment group 1, statistically significant differences were found in all X-ray markings. Twenty-nine of 35 members have a lordosis after treatment compared to 11 of 35 before treatment. The C2 to C7 angle changed an average 13.2°, C1 to horizontal changed an average 9.8°, the anterior head translation reduced an average of 6.8 mm, the average relative rotation angle changed: C2–3: 3.1, C3–4: 5.5, C4–5: 4.80, C5–6: 2.7 and C6–7: 1.1. In the treatment group 2, no statistically significant changes existed between the pre- and posttests except atlas angulation to horizontal which increased an average of 3.0°.

Conclusions: A transformation to a lordotic configuration or increase in lordotic configuration occurred and was measured in the majority of treatment group 1 subjects, while no change in the control group and essentially no change in treatment group 2 was measured. Extension-compression traction combined with diversified chiropractic manipulation and drop table adjusting procedures may improve or partially reestablish the cervical lordosis in 10–14 wk of daily care. (J Manipulative Physiol Ther 1994; 17:454–464).

Key Indexing Terms: Cervical Vertebra, Traction, Chiropractic, Absolute and Relative Rotation Angles.

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Paper submitted October 31, 1991; resubmitted December 9, 1991; and resubmitted April 8, 1993 (then in revised form October 6, 1993 and December 17, 1993).

Funding was provided by: Chiropractic BioPhysics, Non-Profit, Inc., 210 Bent Oak Circle, Harvest, AL 35749.

INTRODUCTION

Chiropractic methods vary tremendously in their assessment of positive clinical outcomes as well as in their methods of achieving these clinical outcomes. Positive outcomes in the clinical setting generally involve some proposed normalization of structural and/or functional components of the musculoskeletal system as a means by which to improve a patient's presenting signs and symptoms. While there is a significant body of literature supporting the role of spinal manipulative therapy (SMT) in various spinal pain syndromes (1–4), there is little if any scientific literature to support the theoretical positions proposed by chiropractors that they can restore so-called "normal" function or structure.

In a more dynamic or functional chiropractic approach, spinal manipulation for intersegmental joint fixations as determined by palpatory methods is extensively utilized. However, studies of inter- and intraexaminer reliability of the detection of the presence or absence of spinal fixation lesions demonstrates no reliability of these methods beyond chance (5, 6). This situation makes it difficult, at this time, to even begin to evaluate chiropractic methods for their effectiveness in achieving the clinical outcome of the theoretical normalization of intersegmental spinal fixations.

However, there is literature to support the reliability of certain radiographic procedures that could be used for the evaluation of the effectiveness of chiropractic methods that claim to alter static spinal alignment (7–9). At this time, there are only two radiographic studies that indicate that manipulative methods may increase cervical lordosis (10, 11). Those studies are in contrast to a recent study by Plaugher et al. (9) that demonstrated no increase in lordosis following chiropractic treatment.

This paper reports on a clinical experiment to investigate the role of two specific treatment regimens in altering static structural alignment in terms of increasing or establishing cervical lordosis. A regimen of diversified type spinal manipulations and drop table adjustments was compared to diversified type spinal manipulation, drop table adjustments and extension-compression traction in the rehabilitation of cervical lordosis. Comparisons were made to a control group that did not receive treatment interventions over a similar time period as the treatment groups. We regard this experimental study as a pilot study to a future and much larger investigation.

Although the clinical relevance of increasing or establishing a cervical lordosis as a treatment goal remains controversial in the chiropractic profession, the assumption made in this paper and by various groups and individuals in the chiropractic profession is that a decrease or loss of cervical lordosis is detrimental to a patient and therefore an attempt to rehabilitate the cervical lordosis should be made (12–14).

Extensive studies by Breig (15) revealed that flexion of the head tractioned the cervical cord, nerve roots and hindbrain. While this physiologic motion is usually well tolerated, sustained flexion may result in the cord and nerve roots being less tolerant to a space occupying lesion such as disk prolapse, posterior spurs, etc. Breig (16) also demonstrated that earlier studies by Taylor (17) had made some erroneous conclusions regarding extension positions of the neck. Taylor's premise that a flexed cervical spine position was desired over a lordotic or extension position was based upon a myelogram study revealing bulges that projected forward into the cervical cord during extension. Taylor incorrectly assumed that this cord bulging was due to the ligamenta flava folding into the neural canal, creating a functional canal stenosis. Breig duplicated Taylor's experiment with various tissues removed in order to determine what structures caused the cervical cord invaginations in extension. He determined that the cervical cord has normal folding in extension caused by the dura attachments and this was responsible for the apparent invagination into the canal, not the ligamenta flava. He further determined that the cord goes through normal unfolding, elastic deformation, and plastic deformation as flexion occurs, rather than the cord, as a whole, moving up and down inside the canal as Taylor thought (Figure 1). Breig determined that lordosis, extension, results in a relaxed, folded cervical cord, while flexion causes tension on all the nerve roots, cranial nerves, cervical cord, and hindbrain.

In addition, Calliet (18) states that if the head weighs 10 pounds, for every inch of anterior weight bearing of the head, a 10-fold increase in the muscle effort of the posterior cervical musculature is required to offset this load. Furthermore, such an anterior displacement of the skull could result in sustained contracture of these muscles and may lead to fibrous infiltration, pain and restricted motion. Hohl (19) identified a relationship between loss of cervical lordosis in auto accident victims and an increase in degenerative changes. Lui and Dai (20) have found the flexed position of the cervical spine, with the cervical lordosis eliminated, to be the most vulnerable axis of the cervical spinal column to trauma. Pal and Sherk (21) have determined that, in lordosis, 64% of the load of the head is transmitted through the cervical articular pillars and only 36% through the vertebral bodies. This suggests that with a loss of lor-

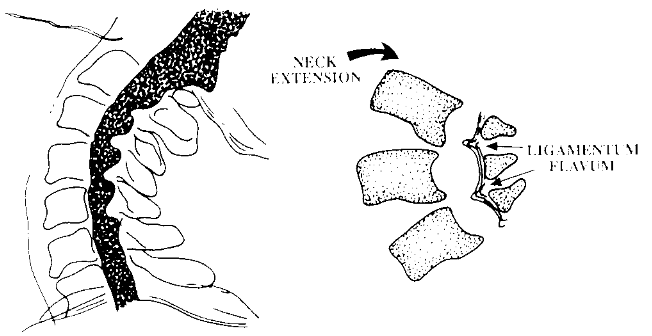

Figure 1. Taylor's false assumption of the ligamentum flavum causing cervical cord compression in extension. Taylor (17) falsely assumed that the ligamentum flavum caused the posterior cord bulging that he observed in cadaver studies in 1953. Breig (15, 16) duplicated Taylor's experiments with various tissues removed and determined that the posterior cord invaginations were caused by the cord relaxing and folding upon itself in the lordotic extended position.

dosis, there may be a resultant loss of the spine's ability to efficiently transmit weight through the cervical area.

Breig utilized a surgical procedure to permanently induce a cervical lordosis in a variety of patients. Besides Breig's surgical procedure, Pierce (12) and Harrison and Robertson (13) have described drop table spinal adjustive techniques designed to induce lordotic configurations in the cervical spine. Unfortunately, beyond anecdotal case presentations in privately published sources, these chiropractic methods have yet to be subjected to any scientific investigation for their effectiveness in establishing or increasing the lordotic cervical curve.

METHODS

Sample Size

Examination of the statistical power that resulted from the sample sizes that were chosen (See Table 1) indicates that the sample sizes were sufficient to detect statistically significant results. All but two of the statistical comparisons have power greater than .90 (beta < .10).

Subjects

For treatment group 1, 41 subjects were randomly selected from the records of 200 consecutive cases at a Saugus, Massachusetts Chiropractic clinic. Six cases were eliminated due to artifacts on the radiographs that could have affected the radiographic examiners learning bias. Thirty-one treatment group 2 subjects were randomly selected from the records of an additional pool of 100 consecutive cases from the same chiropractic office. One subject was eliminated due to an abnormality of the atlantooccipital joint.

Inclusion criteria for the treatment groups required that the patients had completed a prescribed program of care consisting of treatment interventions five days per week for 10–14 wk. Additional inclusion criteria required that pretreatment and posttreatment lateral cervical radiographs had been obtained 12 wk apart (±2 wk) and that all seven cervical vertebrae were clearly visualized on the radiographs.

Thirty control group subjects were chosen from family members of patients at this clinic. All control group subjects were informed of this study and volunteered to participate. Control group subjects agreed to postpone starting chiropractic treatment for 12 wk and informed consent regarding radiograph procedures was obtained following thorough discussion with one of the principal researchers.

There were 13 males and 17 females in the control group, with an average age of 34.8 yr, a range of 23–70 yr and a standard deviation from the average age of 11.1 yr. There were 24 males and 11 females in the treatment group 1, with an average of 34.5 yr, age range of 10–57 yr and a standard deviation from the average age of 10.9 yr. There were 10 males and 20 females in treatment group 2 with an average age of 35.8 yr, age range of 13–62 yr and a standard deviation from the average age of 12.5 yr. All subjects were from the Boston, MA metropolitan area.

Treatment Protocol

While the control group did not receive any chiropractic care, treatment group 1 was treated for 5 days per week for 12 wk (±2 wk). The methods used for treatment group 1 consisted of diversified spinal manipulations in lateral flexion and/or axial rotation, prone drop-table adjustments as described by Harrison and Robertson (13) and extension-compression traction for up to 10 min per treatment session. The treatment frequency and duration was selected based upon the clinical experience of the treating doctors using this method of traction. At the time of the study period, the treating doctors had been performing this method of traction in their practice for approximately 3 yr.

The method of cervical traction used in this study is illustrated in Figure 2 and is termed "extension-compression" traction (22). Patients were screened for risk factors prior to the application of traction. In general, histories of stroke, high blood pressure, diabetes, disk protrusion/prolapse, posterior spurring, or spinal stenosis of space occupying lesion are considered contraindications for extension-compression traction

TABLE 1. Postmeasure differences after adjustment for premeasure differences using the average score of three examiners: treatment group 1 vs. treatment group 2 vs. control: analysis of covariance and power

	Source of variation	df	MS	F	p	Power[a]
Atlas angulation to horizontal	Covariate: Pre-T	1	1086.3	32.2	<.001†	
	Among: TG-1/TG-2/C	2	531.7	15.7	.001*	>.99
	Residual	91	33.7			
Absolute rotation angle	Covariate: Pre-T	1	6358.6	121.4	<.001†	
	Among: TG-1/TG-2/C	2	1113.2	21.2	<.001*	>.99
	Residual	91	52.4			
Anterior head weight bearing	Covariate: Pre-T	1	4458.4	72.6	<.001†	
	Among: TG-1/TG-2/C	2	435.6	7.1	.001*	.92
	Residual	91	61.4			
C2–3	Covariate: Pre-T	1	1460.5	172.7	<.001†	
	Among: TG-1/TG-2/C	2	21.4	2.5	.085	.53
	Residual	91	8.5			
C3–4	Covariate: Pre-T	1	484.6	45.1	<.001†	
	Among: TG-1/TG-2/C	2	186.6	17.3	<.001*	>.99
	Residual	91	10.8			
C4–5	Covariate: Pre-T	1	1643.5	118.5	<.001†	
	Among: TG-1/TG-2/C	2	242.0	17.5	<.001*	>.99
	Residual	91	13.9			
C5–6	Covariate: Pre-T	1	1317.9	152.7	<.001†	.97
	Among: TG-1/TG-2/C	2	78.4	9.1	<.001*	
	Residual	91	8.6			
C6–7	Covariate: Pre-T	1	1429.5	110.8	<.001†	
	Among: TG-1/TG-2/C	2	28.9	2.8	.112	.42
	Residual	91	12.9			

* A family-wise alpha of .05 was used when looking for significance differences among the three groups. Therefore, an alpha of .006 (.05/8) was used for any one significance test.
† This indicates that using a covariate had a significant impact at the .006 alpha level.
[a] "The power of a statistical test is the probability that it will yield statistically significant results" (27).

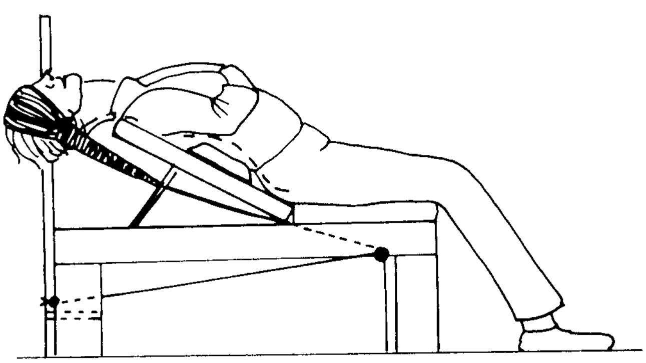

Figure 2. Cervical extension, posterior translation, compression traction. The traction position utilized in this study. The patients were tractioned for up to 10 min daily for 10–14 wk. Treatment and posttreatment lateral cervical radiographs were obtained.

procedure and were consequently excluded from the study. At the start of the traction treatments, patients were placed in the supine position shown in Figure 2; however, the head was supported. Once the patient's tolerance for this position had been established, the patient was placed in extension with the head unsupported. The treatment time was started at 2 min and increased with patient tolerance. Once the patient could tolerate 10 min of unsupported extension, the forehead harness was used to progressively increase the load of the traction.

For treatment group 2, care was the same as for treatment group 1 except cervical traction was not administered. The treatment frequency and duration for this group was maintained the same as for treatment group 1. This frequency and duration of therapy was provided to treatment group 2 so that any differences in outcome that may have occurred between treatment groups 1 and 2 could not be negated by differences in the frequency or duration of the methods utilized, but rather to the differences in the methods used themselves.

Measurement and Curve Classification Procedures

Lateral cervical radiographs were obtained using a Bennett 400-125 X-ray machine, rare earth screens, and an automatic exposure meter to minimize patient exposure. For all radiographic studies (all groups, both pretreatment and posttreatment) subjects were standing for the lateral cervical view and were instructed to flex and extend their head twice with their eyes closed and then assume a neutral, comfortable position.

Three doctors of chiropractic, who were not affiliated with the clinic that provided treatment, served as radiographic examiners. Each of these clinicians made a series of geometric measurements on both the pre- and postradiographs for the control and treatment groups. These measurements included determination of the angular relationships of adjacent vertebrae from C2 through C7 (i.e., C2-3, C3-4, C4-5, C5-6, C6-7). For the purpose of clarity, these adjacent measurements shall be referred to as relative rotation angles. The relationship of the plane of C1 to a horizontal reference line was also measured and shall be referred to as the atlas plane angle. In addition, the Ruth Jackson's angle (23) of the relationship of C2 vs. C7 was also measured and shall be referred to as an absolute rotation angle to differentiate it from the other measurements described. To eliminate learning effect bias, all identifying marks and measurements were removed from the radiographs prior to their presentation to each examiner by the independent research consultant supervising this design.

Figure 3 depicts measurement of the relative rotation angles from C2 through C7 and the absolute angle of C2 compared to C7. In actually drawing these lines, the examiners drew posterior vertebral body lines through the posterior-superior body corner and posterior-inferior body corner of each vertebrae of C2 through C7 rather than constructing perpendiculars to these posterior body lines. Instead of measuring a relative rotation angle between C1 and C2, a line representing the atlas plane is compared to horizontal (Figure 4). In addition to these seven angles, C1 to horizontal, C2 to C7, C2–3, C3 to C4, C4 to C5, C5 to C6, and C6 to C7, anterior head translation (S in Figure 5) is measured in millimeters. This measurement is a forward-backward displacement of C2 to C7. Displacement of the posterior-superior body margin of C2 is measured relative to a vertical axis line (VAL) drawn through the posterior-inferior body margin of C7. Figure 5 represents this displacement, which should be zero in a symmetrical circular lordosis about a gravity line (24). The methods of line drawing analysis used in this study have been meticulously described in a prior study by Jackson et al. (8) where the reliability of this line drawing method was established.

A qualitative description of the lordotic configuration may also be used to evaluate changes in the cervical spine as a result of the therapeutic intervention. The shape of the cervical spine when viewed in the lateral dimension can be classified into the number of apices of deflections as could be done with harmonics for a vibrating string. A first harmonic would refer to those configurations with only one apex (lordotic or kyphotic) or military (straight) in arrangement. A second harmonic configuration would be one with both an area of lordosis and kyphosis, and finally, a third harmonic would refer to a cervical configuration having a kyph-

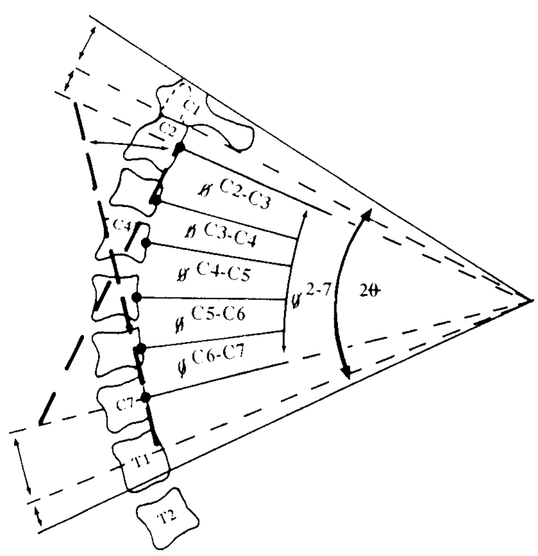

Figure 3. Absolute and relative rotation angles in the cervical spine. Using 2θ as the total arc angle in Figure 3, the mechanical engineering definitions of absolute and relative rotation angles can be applied to the cervical spine in the lateral view (8). If the angle of extension-flexion between adjacent vertebrae is measured, then a relative rotation angle has been determined. The Ruth Jackson physiologic stress lines at the posterior body margins of C2 and C7 determine an absolute rotation angle.

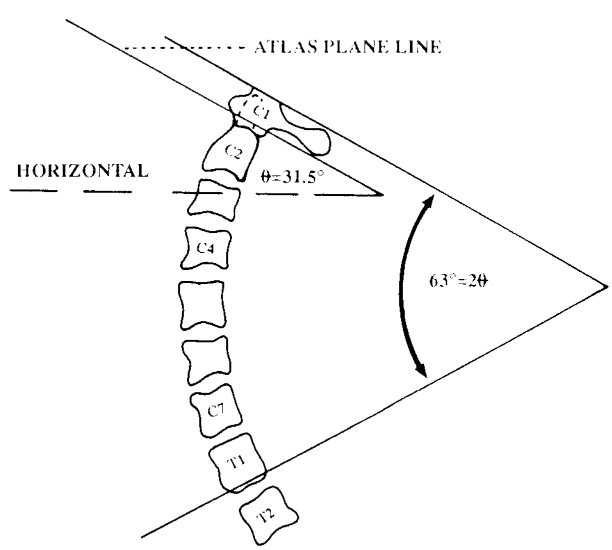

Figure 4. Atlas plane line compared to horizontal. The atlas plane line (APL) was drawn through the interior-posterior anterior arc and interior-anterior of the posterior tubercle. This APL was compared to a horizontal line in degrees.

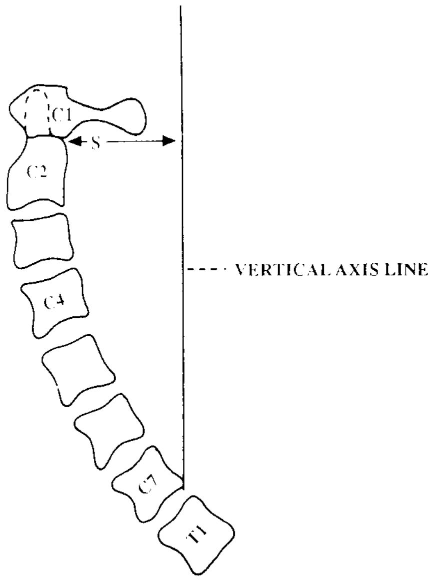

Figure 5. Anterior translation of the upper cervicals. In orthopedic measurements, the dens of C2 is compared to mid C7 body with a vertical line. To use a similar measurement from an easily viewed radiographic landmark, a vertical line from the posterior corner of the body of C7 was compared to a point on the posterosuperior body of C2. This measurement was in millimeters and represents forward translation of the head.

otic area between two areas of lordosis. Figure 6 demonstrates these possible configurations.

Data Analysis

The raw data (C2–3, C3–4, C4–5, C5–6, C6–7, atlas angulation to horizontal, absolute rotation angle, and anterior head weight bearing) were checked for normality and equality of standard deviations using histograms. Further, the data were checked for linearity using scattergrams. This was done on all pre- and postmeasures for treatment group 1, treatment group 2, and the control group for each of the three examiners. Scores from the three examiners were averaged for each variable measured resulting in a pre- and postmeasure average for each score. This averaging should increase the reliability of the measures if examiners are consistent.

A family-wise alpha level of .05 was used for any one set of statistical comparisons. Since there are eight statistical comparisons (C2–3, C3–4, C4–5, C5–6, C6–7, atlas angulation to horizontal, absolute rotation angle and anterior head weight bearing) within any one set when treatment group 1, treatment group 2 and control group differences are compared, an adjusted alpha of .006 (.05/8) was used.

Analyses of variance were calculated on the pretreatment measures among treatment group 1, treatment group 2 and the control group to determine the existence of statistically significant differences in the groups prior to application of treatment. It is reasonable to assume that individuals presenting for treatment in various convenience groups might exhibit statistically significant differences in spinal structures. If such differences exist, they would need to be taken into consideration in the final stages of statistical analysis.

To investigate the presence of any significant change in spinal configuration between treatment group 1, treatment group 2 and the control group; a series of analysis of covariance (ANCOVA) was done. The premeasure average was the covariate and the postmeasure average the dependent variable in all ANCOVAs. As a follow-up to the ANCOVAs, dependent samples t-tests (premeasure average/postmeasure average) were done separately for treatment group 1, treatment group 2 and the control group.

RESULTS

Histograms (not shown) and scattergrams (not shown) were plotted for all measures for all examiners. The data were sufficiently normally distributed, had similar standard deviations and were linear enough to proceed with ANOVA with repeated measures. Cronbach's alpha coefficient reliability estimate, Winer's intraclass correlation coefficient reliability estimate,

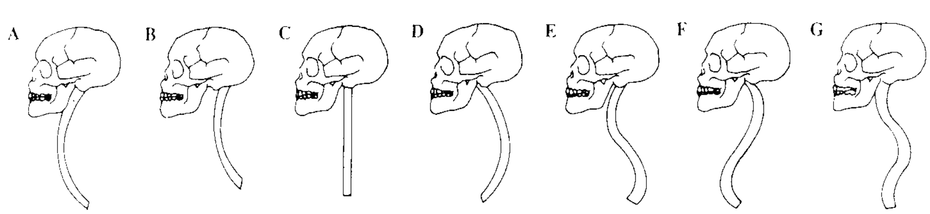

Figure 6. Cervical curve configurations classified as harmonic shapes. In physics, deflections of a vibrating string can be classified into harmonic configurations. Such a classification system can be applied to lateral cervical curves. In A, B, C or D, the first harmonic shapes of normal lordosis, hypolordosis, military and kyphosis are illustrated. In E and F, the second harmonic shapes are illustrated. In G, a third harmonic shape is depicted. The curves of the control and experimental groups were classified this way in this study.

Bartko's adjusted intraclass correlation coefficient reliability estimate, independent samples *t*-tests, analysis of covariance (ANCOVA) and dependent samples *t*-tests. For all further analyses, the average score of the three examiners for each measure was used.

A series ANOVA with repeated measures (Table 2) of the premeasure scores across the three examiners was used to inspect differences across examiners. There were statistically significant differences at the adjusted alpha level of .006 for the atlas angulation to horizontal, the absolute rotation angle, C2–3 and C6–7. For all variables Cronbach's alpha was at least .92, Winer's coefficient estimates were at least .78 and Bartko's adjusted coefficient estimates (his formula 15) were all at least .78.

Analyses of variance (Table 3) were used to examine initial differences among treatment group 1, treatment group 2 and the control group. There were no significant differences at the adjusted alpha level of .006, except for C2–3. These results suggest the use of ANCOVA.

ANCOVA (Table 1) was used to examine differences among treatment group 1, treatment group 2 and the control group on the postmeasure (dependent variable) after adjustment by the premeasure (covariate). In all cases the covariate resulted in a significant adjustment to the dependent variable at the adjusted alpha level of .006. All comparisons among treatment group 1, treatment group 2 and the control group on the postmeasure after adjustment were statistically significant at the adjusted alpha level of .006, except for C2–3 and C6–7. It should also be noted that the large standard deviations compared to the means in Tables 3 and 4 are due to averaging positive and negative values resulting from

TABLE 2. Reliability of premeasures: 95 subject's X-rays across three experts

	Source of variation	*df*	MS	*F*	*p*	Test
Atlas angulation to horizontal	Between X-rays	94	175.5			
	Within X-rays	190	2.8			SPSS alpha = .98
	Between experts	2	16.5	6.15	.003*	Winer's adj. R_I = .96
	Residual	188	2.7			Bartko's (15) r_I = .95
	Total	284	60.0			
Absolute rotation angle	Between X-rays	94	460.0			
	Within X-rays	190	4.2			SPSS alpha = .99
	Between experts	2	23.8	6.00	.003*	Winer's adj. r_I = .99
	Residual	188	4.0			Bartko's (15) r_I = .97
	Total	284	155.0			
Anterior head weight bearing	Between X-rays	94	385.2			SPSS alpha = .94
	Within X-rays	190	23.3			Winer's adj. r_I = .84
	Between experts	2	8.6	.37	.694	Bartko's (15) r_I = .84
	Residual	188	23.4			
	Total	284	143.1			
C2–3	Between X-rays	94	87.0			
	Within X-rays	190	4.9			SPSS alpha = .95
	Between experts	2	37.2	8.08	<.001*	Winer's adj. r_I = .86
	Residual	188	4.6			Bartko's (15) r_I = .85
	Total	284	32.1			
C3–4	Between X-rays	94	78.7			SPSS alpha = .94
	Within X-rays	190	5.0			Winer's adj. r_I = .84
	Between experts	2	20.5	4.28	.015	Bartko's (15) r_I = .83
	Residual	188	4.8			
	Total	284	29.4			
C4–5	Between X-rays	94	95.9		.610	SPSS alpha = .94
	Within X-rays	190	5.8			Winer's adj. r_I = .84
	Between experts	2	2.9	.49		Bartko's (15) r_I = .84
	Residual	188	5.8			
	Total	284	35.6			
C5–6	Between X-rays	94	86.7			
	Within X-rays	190	5.8			SPSS alpha = .93
	Between experts	2	.4	.07	.929	Winer's adj. r_I = .82
	Residual	188	5.9			Bartko's (15) r_I = .82
	Total	284	32.6			
C6–7	Between X-rays	94	92.9			SPSS alpha = .92
	Within X-rays	190	8.0			Winer's adj. r_I = .78
	Between experts	2	43.5	5.69	.004*	Bartko's(15) r_I = .78
	Residual	188	7.7			
	Total	284	36.1			

* A family-wise alpha of .05 was used. Therefore, an alpha of .006 (.05/8) was used for any one significance test for examiner 1 vs. 2 vs. 3.

TABLE 3. Premeasure differences using the average score of three examiners: treatment group 1 vs. treatment group 2 vs. control: analysis of variance

	Pretreatment				Differences				
	Group	*n*	Mean	SD	Source	*df*	MS	*F*	*p*
Atlas angulation to horizontal	TG-1	35	−14.7	7.3	Among	9	71.7	1.23	.297
	TG-2	30	−17.5	8.3	Within	92	58.2		
	C	30	−17.0	7.3					
Absolute rotation angle	TG-1	35	−14.5	10.2	Among	9	372.7	1.13	.328
	TG-2	30	−18.7	13.5	Within	92	152.9		
	C	30	−18.2	13.5					
Anterior head weight bearing	TG-1	35	19.5	13.9	Among	2	29.8	.23	.797
	TG-2	30	21.3	9.9	Within	92	130.6		
	C	30	20.9	9.6					
C2–3	TG-1	35	−1.7†	4.8	Among	2	411.7	8.54	.001*
	TG-2	30	−6.8	5.2	Within	92	24.8		
	C	30	−4.4	5.0					
C3–4	TG-1	35	−1.6	4.0	Among	2	222.7	5.08	.008
	TG-2	30	−5.4	5.3	Within	92	24.1		
	C	30	−3.6	5.4					
C4–5	TG-1	35	−3.1	5.4	Among	2	21.2	.66	.520
	TG-2	30	−1.9	6.4	Within	92	32.2		
	C	30	−1.6	5.2					
C5–6	TG-1	35	−1.8	5.2	Among	2	15.6	.54	.587
	TG-2	30	−.5	5.3	Within	92	29.2		
	C	30	−1.6	5.8					
C6–7	TG-1	35	−5.0	6.2	Among	2	166.0	2.18	.118
	TG-2	30	−4.1	4.8	Within	92	30.2		
	C	30	−7.0	5.3					

* A family-wise alpha of .05 was used. Therefore, an alpha of .006 (.05/8) was used for any one significance test.
† Indicates group that is different from the others based on the Scheffé post-hoc procedure.

TABLE 4. Premeasure/postmeasure changes using the average score of three examiners for treatment group 1, treatment group 2, and the control group: dependent samples *t*-tests

			Pretreatment		Posttreatment		Difference	
Type of measurement	Group	*n*	Mean	SD	Mean	SD	*t*	*p*
Atlas angulation to horizontal	TG-1	35	−14.7	7.3	−24.5	6.8	8.09	<.001*
	TG-2	30	−17.5	8.3	−20.5	6.5	2.13	.042
	C	30	−17.0	7.3	−17.8	7.6	.73	.472
Absolute rotation angle	TG-1	35	−14.5	10.2	−27.7	8.6	7.85	<.001
	TG-2	30	−18.7	13.5	−19.9	11.0	.88	.388
	C	30	−18.2	13.5	−21.1	14.5	2.81	.009
Anterior head weight bearing	TG-1	35	19.5	13.9	12.7	10.4	3.60	.001*
	TG-2	30	21.3	9.9	19.3	10.1	1.48	.148
	C	30	20.9	9.6	20.4	10.4	.37	.712
C2–3	TG-1	35	−1.7	4.8	−4.8	4.3	5.25	<.001*
	TG-2	30	−6.8	5.2	−8.1	5.2	2.59	.015
	C	30	−4.4	5.0	−5.2	4.7	1.31	.201
C3–4	TG-1	35	−1.6	4.0	−7.1	4.4	7.74	<.001*
	TG-2	30	−5.4	5.3	−5.5	4.2	.14	.892
	C	30	−3.6	5.4	−3.6	4.1	.04	.967
C4–5	TG-1	35	−3.1	5.4	−7.9	4.8	6.76	<.001*
	TG-2	30	−1.9	6.4	−2.0	6.3	.10	.924
	C	30	−1.6	5.2	−2.5	5.1	1.78	.085
C5–6	TG-1	35	−1.8	5.2	−4.5	3.8	4.64	<.001*
	TG-2	30	−.5	5.3	−.6	5.5	.20	.843
	C	30	−1.6	5.8	−2.2	4.8	1.00	.325
C6–7	TG-1	35	−5.0	6.2	−6.1	4.7	1.68	.103
	TG-2	30	−4.1	4.8	−3.8	5.1	.34	.739
	C	30	−7.0	5.3	−7.4	5.7	.77	.448

* A family-wide alpha of .05 was used. Therefore, an alpha of .006 (.05/8) was used for any one significance test.
Reliability (coefficient alpha) and the average premeasure standard deviation over all groups were used to calculate the standard error of measurement.

the measurements obtained from lordotic and kyphotic spinal areas in different patients. These measurements have been discussed in detail previously (8).

Follow-up dependent samples *t*-tests (Table 4) demonstrate that no statistically significant changes existed at the adjusted alpha level of .006 between the pre- and postmeasures for treatment group 2 or the control group for any variable measured. This is consistent with predicted results. In contrast, all pre- and postmeasure differences for treatment group 1 were statistically significant at the adjusted alpha level of .006, except for C6–7.

The overview of average changes in spinal configuration from pre- to postmeasures in treatment group 1, treatment group 2 and the control group are shown in Table 5. No significant changes were found in the treatment group 2 or the control group, whereas all changes were significant in treatment group 1 except for C6–7.

The data demonstrate that statistically significant changes occurred in treatment group 1, while little to no change was evident in treatment group 2 or the control group. Following the treatment regimens, the lordotic curves, absolute rotation angle, atlas plane angle, anterior head weight bearing and all five relative rotation angles approximated the values suggested by a theoretical mathematical optimum (24).

Table 6 demonstrates that after treatment, 29 members of the treatment group 1 demonstrated a lordotic curve configuration compared to only 11 prior to treatment. All but one of the 35 treatment group 1 members showed marked change in spinal configuration. From Table 6 it is evident that 24 people in treatment group 1 did not have a cervical lordosis in the pre-X-ray. Of these 24, 18 had a lordosis on the post-X-ray. For those subjects without a cervical lordosis this indicates a return to lordosis of 75% of the cases using cervical compression traction in conjunction with diversified spinal manipulation and drop table adjusting.

At first glance, the cervical curve changes observed in treatment group 1 in this study might be argued to be due to patient positioning for the posttreatment X-ray examination. Our X-ray positioning protocol for this study required the patient to assume a neutral comfortable head position after closing the eyes and flexing and extending the head twice, instead of placing the bite line level to the floor manually. This procedure was used for all pre- and post-X-ray examinations. The extremely close measurements in the pre- and postcontrol group angles, which are equal plus or minus the standard error of measurement (8) for each angle, indicate that this protocol is very reliable for X-ray positioning, and that standing, resting sagittal cervical spine posture is repeatable over a three month period. This finding would be consistent with a recent investigation that demonstrated that the ability of a subject to assume

TABLE 5. Premeasure/postmeasure differences using the average score of three examiners for treatment group 1, treatment group 2 and the control: average change overview from Table 4

Measurement	Group	*n*	Pretreatment mean	Posttreatment mean	Difference
Atlas angulation to horizontal	TG-1	35	−14.7	−24.5	9.8
	TG-2	30	−17.5	−20.5	3.0
	C	30	−17.0	−17.8	.8
Absolute rotation angle	TG-1	35	−14.5	−27.7	13.2
	TG-2	30	−18.7	−19.9	1.2
	C	30	−18.2	−21.1	2.9
Anterior head weight bearing	TG-1	35	19.5	12.7	6.8
	TG-2	30	21.3	19.3	2.0
	C	30	20.9	20.4	.5
C2–3	TG-1	35	−1.7	−4.8	3.1
	TG-2	30	−6.8	−8.1	1.3
	C	30	−4.4	−5.2	.8
C3–4	TG-1	35	−1.6	−7.1	5.5
	TG-2	30	−5.4	−5.5	.1
	C	30	−3.6	−3.6	0.0
C4–5	TG-1	35	−3.1	−7.9	4.8
	TG-2	30	−1.9	−2.0	.1
	C	30	−1.6	−2.5	.9
C5–6	TG-1	35	−1.8	−4.5	2.7
	TG-2	30	−.5	−.6	.1
	C	30	−1.6	−2.2	.6
C6–7	TG-1	35	−5.0	−6.1	1.1
	TG-2	30	−4.1	−3.8	.3
	C	30	−7.0	−7.4	.4

TABLE 6. Pre- and posttreatment cervical curve harmonic classification (review Figure 5)

Group	First harmonics			Second harmonic	Third harmonic
	Lordotic	Military	Kyphotic		
Control group (n = 30)					
Pre	19	0	2	4	5
Post	20	0	2	3	5
Treatment group 1 (n = 35)					
Pre	11	1	2	16	5
Post	29	0	0	5	1
Treatment group 2 (n = 30)					
Pre	14	0	2	6	8
Post	15	0	2	4	9

These curve classifications are based upon the shape of the cervical spine in the lateral view (review Figure 5). The treatment group had an increased percentage of lordotic curves on the post-X-ray.

a comfortable erect sagittal posture is constant up to 2 yr and concludes that, "any postural changes observed during that time are due either to external factors, for which a cause may need to be sought, or to therapeutic influences (25)." Thus, it can be concluded with a reasonable degree of certainty that the treatment group changes were not likely due to X-ray positioning, but rather the therapeutic interventions.

It might be argued that the entire effect may be due to treatment selection bias since there was no selection criteria relative to acute vs. chronic conditions for the various subjects comprising the treatment groups. This possible contention, that acute muscle spasm might cause a patient's loss of or decrease in lordosis prior to treatment and that simply the passage of time would resolve the spasm and return the patient's spinal configuration to a more lordotic configuration, is noted. However, we do not believe that this is a prime factor in the spinal configuration changes observed. One of the contraindications to the use of this type of traction is any sudden increase in symptomatology with traction application, and such a finding would be expected with a patient suffering with acute pain and muscular spasm. As a result, such an occurrence would favor the more acute patient to be included in the nontractioning treatment group; however, since essentially no change in spinal configuration was observed posttreatment in the nontractioning group, selection bias of this type would not account for the observed effects.

The cervical curve changes demonstrated in this study are in contrast to the lack of curve changes found by Plaugher et al. (9) with manipulation. This difference could be due to 1) the more efficient direction of the applied tractioning force vs. those used in chiropractic manipulation and 2) the use of a sustained force. First, we theorize that the changes in the cervical curve require deformation of the anterior longitudinal ligament. Panjabi et al. (26) have shown that the anterior longitudinal ligament experiences strain only in the extension position. Spinal manipulative procedures usually involve some combination of axial rotation and lateral flexion and therefore would not be likely to stress the anterior longitudinal ligament. The extension, posterior translation, and compression force used in this traction method directly stress the anterior longitudinal ligament. Second, soft tissues exhibit creep only with a sustained force, such as traction. It seems unlikely that the sudden impulse force of a chiropractic manual manipulation or drop table adjustive procedure would provide enough time for the soft tissues (anterior longitudinal ligament and anterior disk fibers) to stretch past the elastic phase into the viscous-plastic phase. It appears that the extension-compression traction method may induce a change in cervical lordosis by repeatedly sustaining an extension position and thereby facilitate controlled adaptation of the soft tissues.

CONCLUSION

From this study we conclude that a treatment regimen of diversified spinal manipulation combined with drop table adjustive procedures showed no change in lordosis on post X-ray following 10–14 wk of treatment five times per week. However, a regimen of cervical extension compression traction with diversified spinal manipulation and drop table adjustive procedures over the same duration and frequency may reestablish or increase cervical lordosis.

This study raises many questions regarding the use of these methods in the rehabilitation of cervical lordosis. For example, no quantification of the amount of the applied load was undertaken. Would lesser loads applied over longer time periods be more or less effective than higher loads? What effect would altering the frequency or duration of the treatment have on the amount of induction of lordosis? What effect would traction alone have upon the lordotic configuration?

What effect, if any, did the induction of lordosis have on the symptoms of the patients in treatment group 1 vs. treatment group 2? As with most research, more questions may have been raised than were answered. These are but a few of the areas that require further study that we hope to investigate in future projects.

ACKNOWLEDGMENTS

We wish to thank Anthony Gambale, D.C. for his assistance in data collection and for the use of his clinic facilities in Saugus, MA. Acknowledgment must also be given to Richard Garde, D.C. of Boulder, CO for help in researching relevant literature and Burt Holland, Ph.D., Professor and Chair, Department of Statistics, Temple University, for his editing and evaluation of our statistical analysis.

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