THE JOURNAL OF ALTERNATIVE AND COMPLEMENTARY MEDICINE
Volume 23, Number 9, 2017, pp. 667–675

DOI: 10.1089/acm.2017.0002

Effects of Cervical High-Velocity Low-Amplitude Techniques on Range of Motion, Strength Performance, and Cardiovascular Outcomes: A Review

Xabier Galindez-Ibarbengoetxea, MSc,[1] Igor Setuain, PhD,[2,3] Lars L. Andersen, PhD,[4,5] Robinson Ramírez-Velez, PhD,[6] Miriam González-Izal, PhD,[2] Andoni Jauregi, MD, PhD,[1,7] and Mikel Izquierdo, PhD[2]

Abstract

Background: Cervical high-velocity low-amplitude (HVLA) manipulation technique is among the oldest and most frequently used chiropractic manual therapy, but the physiologic and biomechanics effects were not completely clear.

Objective: This review aims to describe the effects of cervical HVLA manipulation techniques on range of motion, strength, and cardiovascular performance.

Methods/Design: A systematic search was conducted of the electronic databases from January 2000 to August 2016: PubMed ($n = 131$), ScienceDirect ($n = 101$), Scopus ($n = 991$), PEDro ($n = 33$), CINAHL ($n = 884$), and SciELO ($n = 5$). Two independent reviewers conducted the screening process to determine article eligibility. The intervention that included randomized controlled trials was thrust, or HVLA, manipulative therapy directed to the cervical spine. Methodological quality was assessed using the Cochrane risk-of-bias tool. The initial search rendered 2145 articles. After screening titles and abstracts, 11 articles remained for full-text review.

Results: The review shows that cervical HVLA manipulation treatment results in a large effect size ($d > 0.80$) on increasing cervical range of motion and mouth opening. In patients with lateral epicondylalgia, cervical HVLA manipulation resulted in increased pain-free handgrip strength, with large effect sizes (1.44 and 0.78, respectively). Finally, in subjects with hypertension the blood pressure seemed to decrease after cervical HVLA manipulation. Higher quality studies are needed to develop a stronger evidence-based foundation for HVLA manipulation techniques as a treatment for cervical conditions.

Keywords: cervical spine, osteopathic, chiropractic, manipulation, neck

[1]International School of Osteopathy, Bilbao, Spain.
[2]Department of Health Sciences, Public University of Navarra, Navarra, Spain.
[3]Clinical Research Department, TDN, Orthopaedic Surgery and Advanced Rehabilitation Centre, Pamplona, Spain.
[4]National Research Centre for the Working Environment, Copenhagen, Denmark.
[5]Physical Activity and Human Performance Group, SMI, Department of Health Science and Technology, Aalborg University, Aalborg, Denmark.
[6]Centre for Studies on Measurement of Physical Activity, School of Medicine and Health Sciences, Universidad del Rosario, Bogotá, Colombia.
[7]University of Deusto, Bilbao, Spain.

Implications for Practice

- A large effect size was found in cervical range of motion improvement after cervical high-velocity low-amplitude (HVLA) manipulation, especially for patients with neck pain.
- Significant decrease found in blood pressure in subjects with hypertension seems to decrease after cervical HVLA manipulation, especially in diastolic blood pressure.
- Also significant improvements found in pain free handgrip strength increase after cervical HVLA manipulation in patients with lateral epicondylalgia.

Introduction

Spinal manipulative therapy is frequently used by osteopaths, physiotherapists, chiropractors, and doctors. One of the most commonly used techniques involves high-velocity low-amplitude (HVLA) manipulations. Tuchin et al. previously defined HVLA techniques as follows: ''A HVLA technique uses a low-amplitude high-velocity thrust in which vertebrae are carried beyond the normal physiologic range of movement without exceeding the boundaries of anatomic integrity.''[1]

Previous reviews have focused on the effects of cervical HVLA manipulation in relation to neck pain[2–4] and adverse effects after HVLA manipulation treatments of the cervical spine.[5,6] Thus, a gap in the literature exists concerning reviews of cervical HVLA manipulation effects in relation to various other conditions like strength and mobility.

Previous studies have investigated the effects of HVLA manipulation at cervical spine; these effects included a decrease of pain,[7] an increase in mobility,[8] or an improvement in posture.[9] However, several articles described other effects like handgrip strength[10] or temporomandibular joint mobility.[11] In addition to musculoskeletal effects, effects on the cardiovascular,[12] central nervous,[13] and respiratory[14] systems have been described. Thus, rather than focusing on a single condition, this review takes a broad approach and provides an overall review on the effects of cervical HVLA manipulation for various conditions. Indeed, several studies also show inconsistent results particularly with respect to adults, where data are scarce.

In the literature experimental trials have been conducted investigating multimodal conservative treatments for cervical conditions[15]; these studies lacked specificity in reporting effect size outcomes; for this reason, trials that used a combined treatment or that compared cervical HVLA manipulation with other techniques[16] were excluded to investigate the isolated effect of cervical HVLA manipulation.[15]

The aim of this review was to analyze the effects of cervical HVLA manipulation and compare them with control or placebo in randomized controlled study designs on spine and temporomandibular joint mobility, strength, and cardiovascular system.

Methods

The study was undertaken in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, and the method used was based on the minimum criteria established by the Cochrane Back Review Group (CBRG).[17,18]

Literature search

Queries of the literature were performed using the electronic databases PubMed, ScienceDirect, Scopus, PEDro, SciELO, and CINAHL from January 2000 to August 2016. The terms used were: [''Pain'' and ''chiropractic'' OR], [''osteopathic'' and ''trust'' and ''manipulation'' and ''neck'' and ''cervical'' OR]. All Medical Subject Headings terms were combined with pain*, adult*, controlled*, clinical trial*, experimental*, randomized*, strength*, and spine* as limiters. In addition, the reference lists were examined to detect studies potentially eligible for inclusion. Studies reported in languages other than English were not explored.

Eligibility criteria

Study selection. Two of the authors independently screened titles and abstracts of the studies identified by the search strategy. Potentially eligible studies were read in full text and independently evaluated for inclusion in the review.

Data extraction. Two authors (X.G. and M.I.) independently screened the titles and abstracts of potentially eligible studies identified by the search strategy. If necessary, a third researcher (R.R.-V.) was consulted.[18]

Dealing with missing data. If the article did not contain sufficient information, the authors of the article were contacted for additional information. Some authors were asked for more detail on investigation procedure and outcome data.

Types of studies. Randomized controlled trials that investigated the effects of cervical spine HVLA manipulation were included. Studies included only English language peer-reviewed scholarly journals. Designs included parallel and crossover trials. Case reports, case series, single-case studies, dissertations, and conference proceedings were excluded. Authors were contacted to provide missing data or to clarify if data were duplicated in multiple publications. Incomplete data, or data from an already included study, were excluded.

Types of participants. The subjects included symptomatic or asymptomatic humans without any age or sex restrictions.

Types of interventions. The included interventions were HVLA manipulations targeting the cervical spine, regardless of whether cavitation occurred. Cervical HVLA manipulation techniques involving the use of an instrument, such as an activator or other device, were excluded. Single or multiple cervical HVLA manipulation techniques were included, but only those that targeted the cervical spine region. To obtain maximum specificity regarding the cervical HVLA manipulation effects, studies that used multimodal treatments were excluded, that is, trials that used any type of co-interventions, such as electrotherapy, massage, manipulations that were not targeted to the cervical spine, exercise, or other interventions, were excluded. In addition, studies that used a preparatory soft massage were excluded.

Types of comparisons. The comparison group included inactive controls, sham techniques, manual contact, quiet rest, or any form of placebo intervention. Exercise, manipulations not targeted to the cervical spine, medication,

patient education, and other interventions were excluded from the comparison group.

Types of outcome measures. Any type of physiologic measurement, for example, cervical range of motion (CROM) instrument readings, universal caliper, handheld dynamometer readings, or electrocardiogram (ECG), was accepted. Any device or questionnaire used in these techniques must have been validated previously.

Risk of bias in individual studies. For the assessment of the risk of bias of individual studies, the CBRG updated criteria were used.[18] Discussion and consensus were used by two authors (X.G. and M.I.) to resolve disagreements about the methodological quality of the studies assessed in the current review; if necessary, a third researcher (R.R.-V.) was consulted. For a study to be rated as having a low risk of bias, a score equal to or higher than 6 on a scale of 12 items must be obtained. Each assessed item can be scored as ''yes,'' ''no,'' or ''unclear'': ''yes'' if it is included in the article, ''no'' if is not included, and if the article does not provide enough information allowing a yes/no score and the authors could not be contacted, the criteria were scored as unsure. Studies were not excluded from further analyses based on the results of risk-of-bias assessments.

Data analysis and clinical relevance. The effect size was calculated using the mean difference to obtain the Cohen's *d* with a 95% confidence interval (CI). A small effect was defined as Cohen's *d* scores around 0.2. A moderate effect was defined as Cohen's *d* scores around 0.5, and finally scores around 0.8 were considered as a large effect.[19] These outcomes were most likely to be consistently reported across studies and are applicable to clinical practice.

Results

Study selection

In their preliminary search, the titles of 2145 articles were read; of these, 183 were eligible for the next step, which included reading the abstracts. Based on the 183 abstract, 42 were eligible for full-text screening. From the 42 full-text articles, 11 original research studies that investigated the effects of cervical HVLA manipulation are included in Figure 1.

Other studies that investigated the effects of cervical HVLA manipulation combined with other treatment techniques were excluded. Studies that did not include a control or sham group were excluded. Case report studies were excluded.

Study characteristics

Among the 11 eligible studies, most reported on cervical HVLA manipulation and mobility; in the remaining cases, the relationships between cervical HVLA manipulation and strength and cardiovascular system were investigated (Table 1).

Risk of bias within studies

Table 2 reports the methodological score by each criteria developed by CBRG. Out of a total of 11 articles all of them have low risk of bias.

Synthesis of Results and Discussion

Cervical HVLA manipulation and mobility

Cervical HVLA manipulation and cervical spine mobility. Two studies have examined the relationship between cervical HVLA manipulation and cervical spine mobility. Martinez-Segura et al.[8] investigated the immediate effects on CROM after a single HVLA manipulation at the middle cervical spine level in seventy subjects with neck pain of at least 1-month duration. Mechanical neck pain was defined by the authors as generalized neck and/or shoulder pain with mechanical characteristics, including symptoms provoked by maintained neck postures, by neck movement, or by palpation of the cervical muscles, also inclusion requirements for patients to be participants were intervertebral joint dysfunction at C3 through C4 or C4 through C5 levels diagnosed by the lateral gliding test of the cervical spine; this test has shown high inter- and intra-examiner reliability, as well as a good relationship between manual diagnosis and hypomobility.[20,21] Immediately after treatment, cervical HVLA manipulation increased neck flexion by 7°, extension by 8°, left side bending by 5°, right side bending by 5°, left rotation by 9°, and right rotation by 10°. At the CROM the effect size was considered large (>0.80) except in right side bending range of motion (ROM) where the effect size was considered moderate (0.71).[8] However, Passmore et al.[22] investigated mobility improvement after cervical HVLA manipulation in the upper cervical spine. In this case, the dysfunctional level manipulated was C1/C2, and the subjects were asymptomatic with palpable intervertebral motion restriction at the C1–C2 level. The results were different; the only significant improvement found was for right rotation (by 3.75°) with a moderate effect size (0.50) (Table 3).[22] All patients were evaluated with a cervical mobility exploration using a goniometer CROM (Performance Attainment Associates, St. Paul, MN). This device has been validated in several studies and offers a moderate intra-examiner Intraclass Correlation Coefficient (ICC 0.69) and a good inter-examiner ICC (0.75).[23,24] The CROM goniometer had three inclinometers, whose scales ranged from 2° to 2°. These inclinometers are attached to a frame similar to glasses. The CROM device was mounted over the subjects' nose bridge and ears and secured to head by a strap. The frontal and lateral gravity dependent inclinometers measured the side bending and flexion/extension, respectively; instead, the third magnetic dependent inclinometer needed to put a magnetic necklace to measure the rotation. In the starting position the participants were seated relaxed with their feet flat on the floor, their knees and ankles at 90° of flexion, and their hands supported on their thighs.

The difference between these results can be explained in that Martinez-Segura et al.[8] studied patients with neck pain and with important cervical spine ROM limitations, whereas Passmore et al.[22] studied healthy volunteers with dysfunction but with less cervical spine ROM alterations.

Cervical HVLA manipulation and temporomandibular joint mobility. Many studies have investigated the effects of treatments that target the neck to modulate pain in craniofacial regions.[25] The application of treatments directed at the cervical spine may be beneficial in decreasing pain intensity, in increasing pressure pain thresholds over the

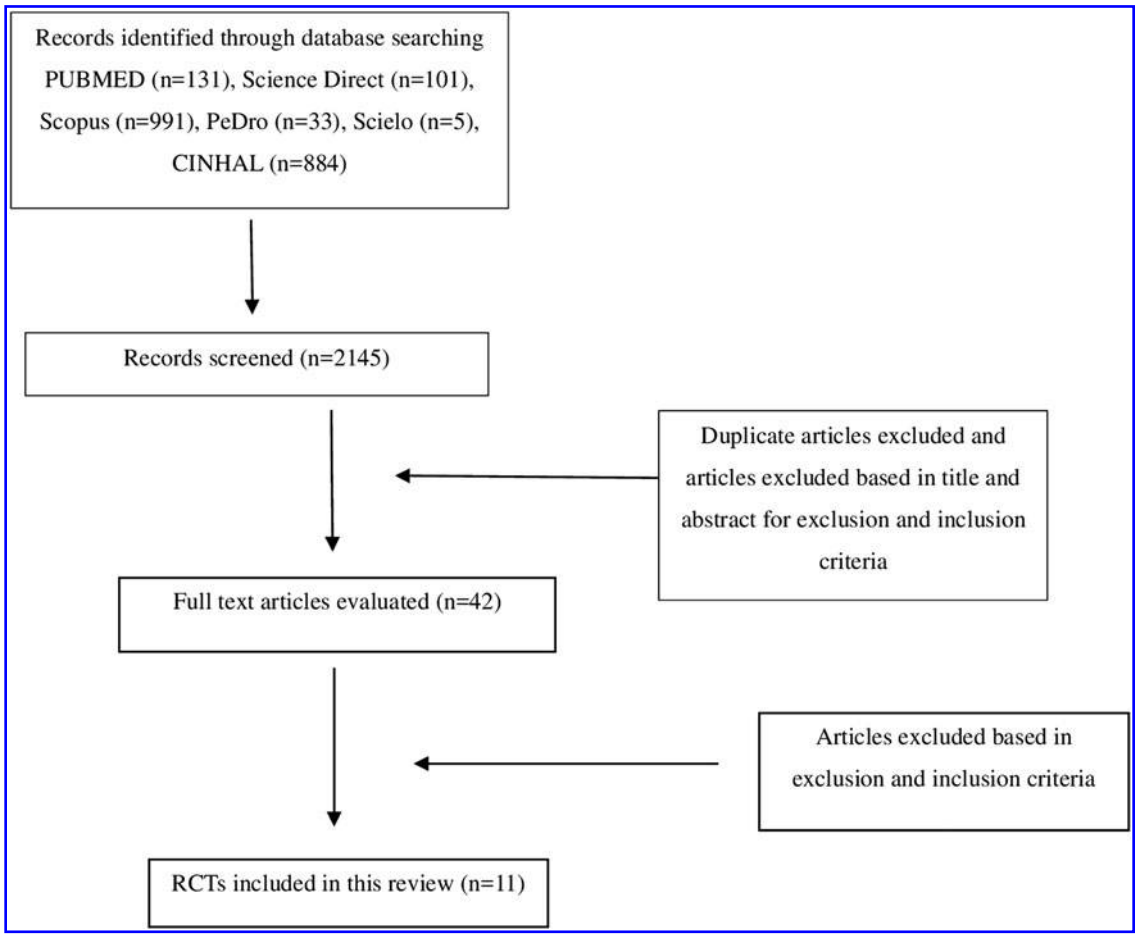

FIG. 1. Study selection flow diagram. RCTs, randomized controlled trials.

mastication muscles, and in increasing pain-free mouth opening (Table 3).[26]

The relationship between mouth opening and cervical HVLA manipulation was studied in three articles. In the first article, George et al.[27] investigated the effect of cervical HVLA manipulation and manual therapy on normal mouth opening in asymptomatic subjects. The intervention applied to the cervical HVLA manipulation group comprised an upper cervical HVLA manipulation at the fixated side. No significant changes were found between the control and cervical HVLA manipulation groups.[27] In contrast, Mansilla-Ferragut et al.[11] found a significant increase in active mouth opening after cervical HVLA manipulation. In this case, the authors investigated the effects of an upper cervical HVLA manipulation on active mouth opening in women with mechanical neck pain; mouth opening was assessed pretreatment and 5 min post-treatment, and a 3.5 mm difference between pre- and postmeasurement was found. Large effect size was considered $d > 1.5$.[11] Oliveira-Campelo et al., in healthy subjects but with latent myofascial trigger points in the masseter muscle on either the left or right side, also found an immediate increase in mouth opening after cervical HVLA manipulation at the C1/C0 joint (1.5 mm), but the effect size was considered small (0.22).[28]

Two different devices were used to measure the active mouth opening. Oliveira-Campelo et al.[28] and Mansilla-Ferragut et al.[11] assessed the active mouth opening as the distance in millimeters between the upper and lower-central dental incisors using a universal caliper. Three consecutive trials were made at 30-sec intervals, and the mean of the three trials was used for data analysis. The intra-assessor reliability has been shown to be high (ICC = 0.90–0.98) for the measurement of mouth opening[29]; however, George et al.[27] used a TheraBite ROM scale, three measurements were taken, and the average score was recorded.

TABLE 1. LIST OF OUTCOME MEASURES AND OTHER DATA EXTRACTED FROM INCLUDED STUDIES

Data	*Type*	*Units*
Cervical mobility	Outcome	Degrees
Temporomandibular joint mobility	Outcome	mm
Strength	Outcome	Kg
Systolic blood pressure	Outcome	mmHg
Diastolic blood pressure	Outcome	mmHg
ECG	Outcome	ms
Heart rate	Outcome	bpm
Program duration	Covariate	Weeks
Session frequency	Covariate	Sessions per week
Year	Year of publication	Year

ECG, electrocardiogram.

Table 2. Detailed Risk-of-Bias Assessment Using the Cochrane Tool

Article	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*Score*
Martinez-Segura et al.[8]	Y	N	Y	N	Y	N	Y	Y	Y	Y	Y	Y	9/12
Passmore et al.[22]	U	N	N	N	Y	N	Y	Y	Y	Y	Y	Y	7/12
George et al.[27]	U	N	N	N	Y	N	Y	Y	Y	Y	Y	Y	7/12
Mansilla-Ferragut et al.[11]	Y	N	N	N	N	N	Y	Y	Y	Y	Y	Y	7/12
Fernandez-Carnero et al.[31]	Y	N	Y	N	Y	N	Y	Y	Y	Y	Y	Y	9/12
Oliveira-Campelo et al.[28]	Y	N	N	N	N	N	Y	Y	Y	Y	Y	Y	7/12
Humphries et al.[30]	U	N	Y	N	Y	N	Y	Y	Y	Y	Y	Y	8/12
Botelho et al.[10]	Y	N	N	N	U	N	Y	Y	Y	Y	Y	Y	7/12
Bakris et al.[32]	Y	N	Y	N	U	Y	Y	Y	Y	Y	Y	Y	9/12
Knutson[12]	U	N	N	N	N	N	U	Y	Y	Y	Y	Y	5/12
Ward et al.[33]	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	9/12

Criteria items: 1, Was the method of randomization adequate? 2, Was the treatment allocation concealed? 3, Was the patient blinded to the intervention? 4, Was the care provider blinded to the intervention? 5, Was the outcome assessor blinded to the intervention? 6, Was the dropout rate described and acceptable? 7, Were all randomized participants analyzed in the group to which they were allocated? 8, Are reports of the study free of suggestion of selective outcome reporting? 9, Were the groups similar at baseline regarding the most important prognostic indicators? 10, Were co-interventions avoided or similar? 11, Was the compliance acceptable in all groups? 12, Was the timing of the outcome assessment similar in all groups?

N, no; U, unsure; Y, yes.

The results obtained in the studies analyzed here are controversial. The most significant increase of mouth opening was found in a study of symptomatic subjects.[11] Considering that the neck pain can decrease mouth opening, treatment with cervical HVLA manipulation in those subjects might improve mouth opening more significantly.[26] In Mansilla-Ferragut et al.[11] study the preintervention active mouth opening was 35.4 (CI = 33.3–37.4) mm and in Oliveira-Campelo et al.[28] and George et al.[27] 46.4 ± 6.8 and 49.5 ± 7.5, respectively.

Cervical HVLA manipulation and strength. Continuing with the possible effects of cervical HVLA manipulation on innervated related tissues, several authors investigated whether cervical HVLA manipulation can improve motor control of the upper limb. Three articles reported the effects of cervical HVLA manipulation on handgrip strength with different conclusions (Table 3).

Humphries et al. investigated the immediate effects of a single C5/C6 HVLA manipulation on right maximum handgrip in recreational basketball players. A marginal improvement (mean, 0.7 kg) was observed for maximum isometric handgrip strength, but this difference was not significant [effect size small (0.07)].[30]

In contrast, Botelho et al. studied elite judo athletes; all cervical levels with dysfunction were manipulated thrice in a 3-week period. The authors found a significant increase in the left (10.53%) and right (16.82%) handgrip strengths.[10]

The manipulation protocol was different between these two studies. Humphries et al.[30] intervention involved a diversified manipulation to the left posterior column of C5–C6 and analyzed the effects immediately; however, Botelho et al.[10] manipulated all cervical levels with dysfunction thrice in a 3-week period. Both studies used a hydraulic hand dynamometer device to measure handgrip isometric strength, for all of that, the results obtained in these two studies are controversial.

In relation to symptomatic subjects, Fernandez-Carnero et al., in a crossover study, investigated the effect of C5/C6 HVLA in patients with lateral epicondylalgia (LE).[31] The authors studied the maximum pain-free handgrip strength (PFG) on the affected side and the maximum handgrip strength on the other side (HGS). The application of HVLA manipulation at C5/C6 produced an immediate increase of PFG on the affected side at 37.8% [with a large effect size (0.78)]; on the unaffected side, the results obtained were similar to those obtained by Humphries et al. and were not significant [small effect size (0.05)].[30]

Cervical HVLA manipulation and cardiovascular system. Bakris et al. in their pilot study concluded that during restoration of the atlas alignment using a HVLA technique once a week during 8 weeks in patients with hypertension stage 1, blood pressure (BP) descended more than placebo technique; the results obtained were similar to those obtained in studies using drug therapy. In contrast, heart rate was not reduced.[32] Consistently, Knutson found a significant decrease in systolic BP of 10.3 mmHg [effect size moderate (0.42)]. However, the authors did not observe significant changes in heart rate or diastolic BP.[12]

In contrast, Ward et al. studied 48 healthy subjects; the cervical HVLA manipulation group intervention involved a C1 rotation technique. No statistically significant differences were shown for ECG, bilateral pulse oximetry, and bilateral BP in any between-group comparisons of cardiovascular-dependent variables.[33]

These different findings might be explained as follows: in the studies of Knutson[12] and Bakris et al.[32] the dysfunction of the subjects was diagnosed; however, in the study of Ward et al.,[33] the subjects were randomized into four groups. In this last case, the cervical HVLA manipulation technique used might not have been the most appropriate. Perhaps if the study were conducted in hypertensive patients with real dysfunction and adequate correction at C1 the results might have been different to those observed by Bakris et al.[32] (Table 3).

Only in Bakris et al.[32] study followed a validated protocol to measure BP, the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure.[34]

TABLE 3. SUMMARY OF STUDIES THAT INVESTIGATED THE EFFECTS OF CERVICAL HIGH-VELOCITY LOW-AMPLITUDE MANIPULATION ON CERVICAL AND TEMPOROMANDIBULAR RANGE OF MOTION, STRENGTH, AND THE CARDIOVASCULAR SYSTEM

Study	*Subjects* (n)	*Groups*	*Group size*	*Intervention*	*Intervention duration*	*Frequency (days/week)*	*Outcomes*	*Effect size of cervical HVLA*[a]
Mobility (cervical)								
Martinez-Segura et al.[8]	48 (16 male, 32 women, 18–48 years of age)	Cervical HVLA	34	HVLA C3/C4 or C4/C5 (experimental)	One session	0	↑ Flexion 7°	Flexion 1 (0.49 to 1.49)
							↑ Extension 8°	Extension 0.89 (0.38 to 1.38)
							↑ Left side bending 5°	Left side bending 0.83 (0.33 to 1.32)
							↑ Right side bending 5°	Right side bending 0.71 (0.22 to 1.20)
							↑ Left rotation 9°	Left rotation 0.95 (0.43 to 1.44)
		Control	37	Placebo mobilization (control)			↑ Right rotation 10°	Right rotation 1.17 (0.65 to 1.67)
Passmore et al.[22]	$n=15$ Age 29.1 ± 6.5 (experimental) and 26.5 ± 5.7 (control) Men and women asymptomatic but with dysfunction in C1/C2	Cervical HVLA	8	HVLA C1/C2 (experimental)	One session	0	↑ Right rotation 3.75° No significant changes in flexion, extension, left rotation, right side bending, and left side bending	Right rotation 0.50 (–0.52 to 1.47)
		Control	7	No intervention (control)				
Mobility (TMJ)								
George et al.[27]	$n=101$ Age 24.6 ± 2.6 Men and women asymptomatic	Cervical HVLA	34	HVLA C1/C2 (experimental)	One session	0	No significant changes in PFMO	PFMO 0.01 (–0.46 to 0.49)
		Control	33	No intervention (control)				
Mansilla-Ferragut et al.[11]	$n=37$ Age 36 ± 7 (experimental) and 34 ± 8 (control) Women with neck pain	Cervical HVLA	18	HVLA C0/C1 (experimental)	One session	0	↑ 3.5 mm PFMO	PFMO >1.5
		Control	19	Manual contact (control)				
Oliveira-Campelo et al.[28]	$n=122$ Age 35 ± 10 (experimental) and 39 ± 10 (control) Men and women asymptomatic with trigger point in masseter muscle	Cervical HVLA	41	HVLA C0/C1 (experimental)	One session	0	↑ 1.5 mm PFMO	PFMO 0.22 (–0.22 to 0.65)
		Control	40	No intervention (control)				
Handgrip strength								
Humphries et al.[30]	$n=24$ Age 26.3 ± 8.5 (experimental) and 26.3 ± 10 (control) Men asymptomatic	Cervical HVLA	12	HVLA C5/C6 (experimental)	One session	0	No significant changes in HGS	HGS 0.07 (–0.73 to 0.87)
		Control	12	Placebo activator (control)				

(*continued*)

TABLE 3. (CONTINUED)

Study	*Subjects* (n)	*Groups*	*Group size*	*Intervention*	*Intervention duration*	*Frequency (days/week)*	*Outcomes*	*Effect size of cervical HVLA*[a]
Botelho et al.[10]	$n=18$ Men and women asymptomatic elite athletes.	Cervical HVLA	9	HVLA at dysfunction levels once a week during 3 weeks (experimental)	3 sessions	1	↑ Left 10.53% in HGS ↑ Right 16.82% in HGS	Not found—no SD
		Control	9	Sham technique (control)				
Fernandez-Carnero et al.[31]	$n=10$ Age 42 ± 6 Men and women with lateral epicondylalgia	Cervical HVLA	10	HVLA C5/C6 (experimental)	One session	0	No changes in HGS ↑ 37.8% in PFG	HGS 0.05 (–0.93 to 0.82) PFG 0.78 (–0.16 to 1.66)
		Control	10 (crossover)	Manual contact (control)				
Cardiovascular system								
Bakris et al.[32]	$n=50$ Age 53.6 ± 8.6 (experimental) and 51.8 ± 10.9 (control) Men and women with hypertension stage 1 and dysfunction at C1	Cervical HVLA	50	HVLA C1/C2 (experimental) once a week during 8 weeks	8 sessions	1	↓ 17.2 mmHg SBP ↓ 10.3 mmHg DBP	Not found—no SD
		Control	50	Sham technique (control)			No significant changes in HR	
Knutson[12]	$n=80$ Age 53 (21–83 range) (experimental) and 54 (20–83 range) (control) Men and women with and without hypertension but with dysfunction in C1/C2	Cervical HVLA	40	HVLA C1/C2 (experimental)	One session	0	↓ 10.3 mmHg DBP No significant changes in SBP and HR	SBP 0.42 (–0.05 to 0.87)
		Control	40	Sham mobilization (control)				
Ward et al.[33]	$n=48$ Age 27 ± 4.5 (experimental 1) 25.5 ± 2.9 (experimental 2) 25.1 ± 2.1 (control 1) 26.5 ± 2.6 (control 2) Men and women asymptomatic	Cervical HVLA	12/12	HVLA C1/C2 right (experimental 1) HVLA C1/C2 left (experimental 2)	One session	0	No significant changes in SBP, DBP, ECG, BPO	No significant changes
		Control	12	No Neck contact (control 1) sham mobilization (control 2)				

Effect sizes were calculated using Cohen's *d* coefficient, an effect size >0.8 was considered large, an effect size of ~0.5 was considered moderate, and an effect size of <0.2 was considered small.

[a]Calculated by the authors of this review.

↑, increase; ↓, decrease; BPO, bilateral pulse oximetry; DBP, diastolic blood pressure; ECG, electrocardiogram; HGS, handgrip strength; HVLA, high-velocity low-amplitude; PFG, pain-free handgrip strength; PFMO, pain-free mouth opening; HR, heart rate; SBP, systolic blood pressure; SD, standard deviation; TMJ, temporomandibular joint.

Conclusion

This review shows that cervical HVLA manipulation results in improvements of mobility, as well as in the cardiovascular system. A large effect size was found in CROM improvement, especially for patients with neck pain. Rotation was the most clearly improved movement. In addition, mouth opening without pain was improved after upper cervical HVLA manipulation, mainly in patients with neck pain.

Regarding handgrip strength, no significant changes were found after cervical HVLA manipulation; however, free handgrip improved after cervical HVLA manipulation in patients with LE pain. The effects of cervical HVLA manipulation at C5/C6 in electromyography were contradictory, and further research is warranted.

In respect of the relationship between upper cervical HVLA manipulation and the cardiovascular system, a decrease in diastolic BP was found; however, for other studied variables, such as heart rate, systolic BP, electrocardiogram, and bilateral pulse oximetry, the changes were not significant.

In summary, studies that examined symptomatic subjects and real dysfunctions showed better improvement than others; this might indicate that the effects of cervical HVLA manipulation were related more to the recovery of limitations than to improvements in mobility, strength, and other parameters. Higher quality studies are needed to develop a stronger evidence-based foundation for HVLA techniques as a treatment for cervical conditions.

Acknowledgments

The authors declare that they have no competing interests. This research received no grant from any funding agency in the public, commercial, or not-for-profit sectors.

Ethical Statement

The study was a review. It did not involve experimentation on human subjects and therefore did not require approval from an institutional ethics committee.

Author Disclosure Statement

No competing financial interests exist.

References

1. Tuchin PJ, Pollard H, Bonello R. A randomized controlled trial of chiropractic spinal manipulative therapy for migraine. J Manipulative Physiol Ther 2000;23:91–95.
2. Gross AR, Hoving JL, Haines TA, et al. Manipulation and mobilisation for mechanical neck disorders. Cochrane Database Syst Rev 2004;1:CD004249.
3. Gross AR, Kay TM, Kennedy C, et al. Clinical practice guideline on the use of manipulation or mobilization in the treatment of adults with mechanical neck disorders. Man Ther 2002;7:193–205.
4. Haneline MT. Chiropractic manipulation and acute neck pain: A review of the evidence. J Manipulative Physiol Ther 2005;28:520–525.
5. Ernst E. Adverse effects of spinal manipulation: A systematic review. J R Soc Med 2007;100:330–338.
6. Haynes MJ, Vincent K, Fischhoff C, et al. Assessing the risk of stroke from neck manipulation: A systematic review. Int J Clin Pract 2012;66:940–947.
7. Ruiz-Saez M, Fernandez-de-las-Penas C, Blanco CR, et al. Changes in pressure pain sensitivity in latent myofascial trigger points in the upper trapezius muscle after a cervical spine manipulation in pain-free subjects. J Manipulative Physiol Ther 2007;30:578–583.
8. Martinez-Segura R, Fernandez-de-las-Penas C, Ruiz-Saez M, et al. Immediate effects on neck pain and active range of motion after a single cervical high-velocity low-amplitude manipulation in subjects presenting with mechanical neck pain: A randomized controlled trial. J Manipulative Physiol Ther 2006;29:511–517.
9. Smith L, Mehta M. The effects of upper cervical complex high velocity low amplitude thrust technique and suboccipital muscle group inhibition techniques on standing balance. Int J Osteopath Med 2008;11:162.
10. Botelho MB, Andrade BB. Effect of cervical spine manipulative therapy on judo athletes' grip strength. J Manipulative Physiol Ther 2012;35:38–44.
11. Mansilla-Ferragut P, Fernandez-de-Las Penas C, Alburquerque-Sendin F, et al. Immediate effects of atlanto-occipital joint manipulation on active mouth opening and pressure pain sensitivity in women with mechanical neck pain. J Manipulative Physiol Ther 2009;32:101–106.
12. Knutson GA. Significant changes in systolic blood pressure post vectored upper cervical adjustment vs resting control groups: A possible effect of the cervicosympathetic and/or pressor reflex. J Manipulative Physiol Ther 2001;24:101–109.
13. Taylor HH, Murphy B. Altered sensorimotor integration with cervical spine manipulation. J Manipulative Physiol Ther 2008;31:115–126.
14. Da Silva PHL, De Ré D, Behne GR, et al. Maximum respiratory pressure alterations after spinal manipulation. Eur J Physiother 2013;15:64–69.
15. Evans R, Bronfort G, Schulz C, et al. Supervised exercise with and without spinal manipulation performs similarly and better than home exercise for chronic neck pain: A randomized controlled trial. Spine (Phila Pa 1976) 2012; 37:903–914.
16. Bronfort G, Evans R, Anderson AV, et al. Spinal manipulation, medication, or home exercise with advice for acute and subacute neck pain: A randomized trial. Ann Intern Med 2012;156:1–10.
17. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: Explanation and elaboration. BMJ 2009;339:b2700.
18. Furlan AD, Pennick V, Bombardier C, van Tulder M; Editorial Board, Cochrane Back Review Group. 2009 updated method guidelines for systematic reviews in the Cochrane Back Review Group. Spine (Phila Pa 1976) 2009;34:1929–1941.
19. Cohen J. Statistical Power Analysis for the Behavioural Sciences. 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc., 1998.
20. Fernandez-de-las-Penas C, Downey C, Miangolarra-Page JC. Validity of the lateral gliding test as tool for the diagnosis of intervertebral joint dysfunction in the lower cervical spine. J Manipulative Physiol Ther 2005;28:610–616.
21. Rey-Eiriz G, Alburquerque-Sendin F, Barrera-Mellado I, et al. Validity of the posterior-anterior middle cervical spine gliding test for the examination of intervertebral joint hypomobility in mechanical neck pain. J Manipulative Physiol Ther 2010;33:279–285.
22. Passmore SR, Burke JR, Good C, et al. Spinal manipulation impacts cervical spine movement and fitts' task performance:

A single-blind randomized before-after trial. J Manipulative Physiol Ther 2010;33:189–192.
23. Youdas JW, Carey JR, Garrett TR. Reliability of measurements of cervical spine range of motion—Comparison of three methods. Phys Ther 1991;71:98–104; discuss 105–106.
24. Florencio LL, Pereira PA, Silva ER, et al. Agreement and reliability of two non-invasive methods for assessing cervical range of motion among young adults. Rev Bras Fisioter 2010;14:175–181.
25. La Touche R, París-Alemany A, Mannheimer JS, et al. Does mobilization of the upper cervical spine affect pain sensitivity and autonomic nervous system function in patients with cervico-craniofacial pain?: A randomized-controlled trial. Clin J Pain 2013;29:205–215.
26. La Touche R, Fernandez-de-las-Penas C, Fernandez-Carnero J, et al. The effects of manual therapy and exercise directed at the cervical spine on pain and pressure pain sensitivity in patients with myofascial temporomandibular disorders. J Oral Rehabil 2009;36:644–652.
27. George JW, Fennema J, Maddox A, et al. The effect of cervical spine manual therapy on normal mouth opening in asymptomatic subjects. J Chirpract Med 2007;6:141–145.
28. Oliveira-Campelo NM, Rubens-Rebelatto J, Marti N-Vallejo FJ, et al. The immediate effects of atlanto-occipital joint manipulation and suboccipital muscle inhibition technique on active mouth opening and pressure pain sensitivity over latent myofascial trigger points in the masticatory muscles. J Orthop Sports Phys Ther 2010;40:310–317.
29. Goulet JP, Clark GT, Flack VF, Liu C. The reproducibility of muscle and joint tenderness detection methods and maximum mandibular movement measurement for the temporomandibular system. J Orofac Pain 1998;12:17–26.
30. Humphries KM, Ward J, Coats J, et al. Immediate effects of lower cervical spine manipulation on handgrip strength and free-throw accuracy of asymptomatic basketball players: A pilot study. J Chiropr Med 2013;12:153–159.
31. Fernandez-Carnero J, Fernandez-de-las-Penas C, Cleland JA. Immediate hypoalgesic and motor effects after a single cervical spine manipulation in subjects with lateral epicondylalgia. J Manipulative Physiol Ther 2008;31:675–681.
32. Bakris GL, Dickholtz M, Sr, Meyer P, et al. Atlas vertebra realignment and achievement of arterial pressure goal in hypertensive patients: A pilot study. J Vertebral Subluxation Res 2007;10:1–9.
33. Ward J, Tyer K, Coats J, et al. Immediate effects of atlas manipulation on cardiovascular physiology. Clin Chiropract 2012;15:147–157.
34. Chobanian AV, Bakris GL, Black HR, et al. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: The JNC 7 report. JAMA 2003;289:2560–2572.

Address correspondence to:
Mikel Izquierdo, PhD
Department of Health Sciences
Public University of Navarra
Campus of Tudela
Avenida Tarazona, s/n
Tudela, Navarra 31500
Spain

E-mail: mikel.izquierdo@gmail.com