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Case Study

# Re-establishing the cervical lordosis after whiplash: a Chiropractic Biophysics® spinal corrective care methods pre-auto injury and post-auto injury case report with follow-up

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**Abstract.** [Purpose] To document the re-establishment of the cervical lordosis following radiographically verified altered sagittal plane alignment both prior to, and following a motor vehicle collision. [Participant and Methods] A 16-year-old male presented for a non-motor collision complaint of low back pain. Initial lateral cervical radiograph demonstrated cervical hypo-lordosis. The patient was treated with a 6-week plan (18 visits) utilizing Chiropractic BioPhysics® (CBP) methods to increase the cervical lordosis. Eight months later the patient presented with new complaints as a result of a motor collision. The cervical lordosis straightened. The patient received another round of similar treatment to improve the lordosis. There was also a 6.5-month follow-up. [Results] The initial round of treatment achieved a 21° improvement in cervical lordosis. The motor vehicle collision caused a loss of 15° of lordosis. The second round of treatment achieved a 12.5° improvement in lordosis that was demonstrated to be maintained at a 6.5-month follow-up. [Conclusions] This case illustrates how a whiplash event occurring during a motor vehicle collision subluxated the cervical spine. It was also shown that CBP methods reliably corrected the lordosis after two separate treatment programs using specialized methods. Beyond trauma, radiographic screening of specific cervical subluxation is recommended following all motor collisions.

**Key words:** Cervical spine, Whiplash, Subluxation

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## INTRODUCTION

The alignment of the cervical spine is becoming recognized as an important biomechanical biomarker in the health and wellness of patients who present with various craniocervical ailments including neck pains, headaches, dizziness, etc[1–5)].

The clinical assessment of patients who present with cervical spine disorders requires a radiographic exam to screen for important biomechanical relationships[6, 7)]. Important sagittal image metrics include the cervical lordosis and anterior head translation (AHT).

Whiplash involves the forceful, rapid back-and-forth movement of the neck resulting in neck injury[8)]. Biomechanically, whiplash has been demonstrated to cause a cervical 'S-curve' subluxation within 100 milliseconds that involves posterior head translation, lower cervical hyperextension, and mid-upper cervical hyperflexion[9, 10)]. Although the cervical subluxation induced in the neck during a whiplash event has been documented in the lab, few pre-post radiographic illustrations of the biomechanical effects of whiplash on the cervical spine have been recorded on patients from real life events[11)]. Harrison et al. presented a series of 41 patients radiographically assessed after an MVC who also had recent prior imaging which allowed

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an analysis of the effects resulting from the MVC to the alignment of the cervical spine[11]. It was determined that an average loss of 10° lordosis resulted from the collision[11].

Recent evidence has indicated that cervical spine alignment is important in determining the outcome in whiplash injured patients[12]. Indeed, recent case reports have documented that improvement in cervical spine parameters have led to successful outcomes in patients who have been involved in whiplash events[13–17]. None of these cases however, have documented the biomechanical effects of the whiplash event on the cervical spine as patients first sought treatment following their injury. There is an urgent need for the documentation of the effects of MVC on the cervical spine to ascertain cause and effect in terms of subluxation and its pathologic sequelae.

The purpose of this case is to document the re-establishment of the cervical lordosis following radiographically verified subluxation (altered sagittal plane alignment) following a motor vehicle collision (MVC). Since the reason a pre-collision image existed is due to previous treatment, this case presents the results of Chiropractic BioPhysics® (CBP®) technique procedures directed at increasing the cervical lordosis both prior to an MVC as well as afterwards and also includes a follow-up.

## PARTICIPANT AND METHODS

A 16-year-old male initially presented to the first author for a non-MVC complaint of low back pain (LBP). The patient rated their LBP an average of 5/10 on an 11-point numeric pain rating scale (NPRS: 0=no pain; 10=worst pain ever). The Oswestry low back pain disability index (ODI) was scored as 30%. Physical exam findings included paraspinal tenderness upon palpation; mild to moderate for the cervical, mild for the thoracic and mild to moderate for the lumbar spinal area. Range of motion (ROM) indicated no restriction in the cervical or lumbar areas, however, there was a mild increased pain upon right cervical lateral bending and it radiated into the right scapula (2/10). There was also a mild increased pain upon lumbar flexion and extension (2/10). Milgram's test was positive and elicited LBP rated as a 2/10. Reflexes were normal. All other tests were unremarkable.

The patient had a radiographic assessment and the images were digitized within the PostureRay™ EMR software system (PostureCo., Trinity, FL, USA). Sagittal images are quantified using the Harrison posterior tangent method[18, 19] which draws lines contiguous with the posterior vertebral body margins. The global cervical lordosis is measured by the intersection of C2-C7 tangent lines, anterior head translation (AHT) is measured by the horizontal distance between a vertical line drawn from the posterior-inferior corner of C7 body relative to the offset of the posterior-superior corner of C2 body. The atlas plane line (APL) is estimated as a best fit line bisecting the C1 midline relative to a true horizontal. These metrics are reliable and repeatable[18, 19]. The initial lateral cervical image indicated a straightened lordosis (ARA=−12.1°), AHT (27.4 mm) and an APL of −20.4° (Table 1; Fig. 1).

**Table 1.** Details of radiographic metrics

| | Pre-txt<br>1/20/21 | Post-txt<br>3/22/21 | Pre-txt<br>12/1/21 | Post-txt<br>1/31/22 | F/u<br>8/18/22 |
|---|---|---|---|---|---|
| ARA (°) | −12.1 | −33 | −17.6 | −29.9 | −31.7 |
| TzH (mm) | 27.4 | 31 | 22.9 | 20.9 | 22.5 |
| APL (°) | −20.4 | −29.3 | −25.4 | −34.7 | −30.3 |
| NDI (%) | 0% | 0% | 22% | 8% | 4% |
| ODI (%) | 30% | 22% | DNP | DNP | 8% |

ARA: absolute rotation angle for cervical lordosis from C2-C7; TzH: anterior head translation from C2-C7; APL: atlas plane angle to horizontal; NDI: neck disability index; ODI: Oswestry disability index; Txt: treatment; F/u: follow up; DNP: did not perform.

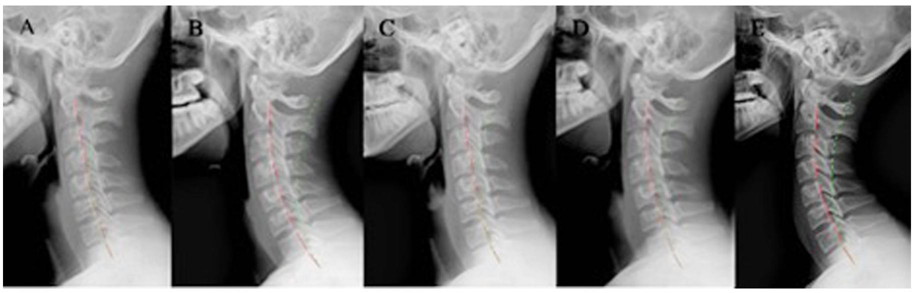


**Fig. 1.** Lateral cervical X-rays. A and B: Pre-post lordosis improvement prior to the motor vehicle collision (MVC); C: Alignment after the MVC (vs. B); C and D: Pre-post lordosis improvement following MVC; E: 6.5-month follow-up following post-MVC lordosis correction (D).

The patient was treated with a 6-week plan (18 visits at 3× a week) utilizing CBP methods to increase the cervical lordosis[20–24]. CBP technique is a full-spine, spine and posture correcting technique that incorporates spinal traction, corrective exercises and postural adjustments in a unique mirror image® application. It is noted that treatment was provided to the whole spine, however, due to the significant cervical hypolordosis, 'structural rehabilitation' was utilized to increase the cervical lordosis; this was not necessary for the lumbar spine. On the second visit the patient started a seated compression-extension 2-way traction[25], which was continued thereafter (Fig. 2). The traction weighting was increased to a 17-pound pull on the front and a 5-pound pull on the back, for a duration of 10 minutes per session. Full-spine, spinal manipulative therapy (SMT) was provided using high-velocity, low-amplitude manual forces to cavitate the cervical, thoracic and lumbar facet joints in order to decrease pain and improve spinal function. CBP posture adjusting for AHT was also performed involving a height adjustable head piece forcing the patient's head to be translated posteriorly relative to the thoracic cage as they lay prone. Next, pressure onto the dorsal spine engages a drop mechanism; thereby causing the thoracic table surface to give way approximately 2–3 cm. The thoracic piece accelerates downward until it rapidly stops; this causes a subtle jolt to the spinal structures of the cervicothoracic spine thought to stimulate mechanoreceptors. A cervical extension traction orthotic, the Denneroll™ (Denneroll Spinal Orthotics, Wheeler Heights, NSW, Australia) was prescribed to be performed at home on a daily basis after the 1st week of care.

At the end of the treatment sessions, the patient remained on a once-a-month adjustment schedule for 8-months before presenting with new complaints 2-weeks following an MVC. Details of the collision include the patient as the driver, he was wearing a seat belt and the air bag was deployed. The patient struck a stopped car in front while slowing down and was aware of the impending collision.

The post-MVC assessment revealed a primary complaint of neck pain with an NDI score of 22%. The patient rated their neck pains as a 3–4/10 and LBP as a 4/10. There was moderate paraspinal tenderness over the cervical and lumbar areas, and mild tenderness over the thoracic areas. There was a decreased right cervical ROM (70°/80°) with stiffness and soreness on left and right rotation and lateral bending. Lumbar ROM was normal with moderate LBP pain (4/10) in extension and left rotation. Cervical compression and other orthopedic tests were negative. Reflex testing and muscle strength tests were normal. Dermatomal testing and cranial nerve testing were also unremarkable.

The post-MVC treatment involved a similar 6-week care plan as compared to the initial pre-MVC plan (i.e. 18 visits at 3× a week). On the second visit, a seated compression-extension 2-way cervical extension traction was started (Fig. 2). The traction weighting was increased to a 15-pound pull on the front and a 5-pound pull on the back, for a duration of 10 minutes per session. Again, full-spine SMT and CBP posture adjusting for AHT were performed. The last 10 sessions involved a cervical extension exercise comprised of standing on a vibration plate (PowerPlate™) and holding a neck resistance band where the patient first slightly anteriorly translated the head then "scooped" the neck backward into extension and then posteriorly translated the head; thereafter, the arms would be extended to add resistance to the tension band and held for a 3 count with 3 second rests in between repetitions (Fig. 3). This would be continued for 5 minutes. Again, a home Denneroll orthotic was prescribed after the first week of care to be performed daily.

The results from the first and second round of CBP treatment directed at improving the cervical lordosis is described next as well as the biomechanical effect of the MVC on the cervical lordosis. There is also a 6.5-month follow-up. The patient (and parents) consented to the report of these results.

**Fig. 2.** Cervical extension traction. Seated compression-extension 2-way traction causes anterior longitudinal ligament, anterior intervertebral disc and anterior muscular tissue creep and plastic deformation to increase cervical lordosis.

**Fig. 3.** Corrective exercise. Anterior head translation followed by head extension followed by posterior head translation induces a cervical hyper-extension against elastic resistance.

## RESULTS

The results after the first round of treatment (pre-MVC) resulted in improvement in LBP, a 0/10 NPRS (vs. 5/10) and a 22% ODI (vs. 30%), There was resolved paraspinal tenderness in the cervical and thoracic spine, however, mild tenderness persisted in the lumbar spine. There was no restriction or pain elicited for ROM in the cervical or lumbar spine. Milgram's test was negative for pain in the low back. Radiographic changes in the sagittal cervical image after the first round of CBP rehabilitation resulted in a 20.9° improved lordosis (−33° vs. −12.1°), an 8.9° improved APL, and a slight increase in AHT (31 mm vs. 27.4 mm).

Upon the patient reporting after the MVC, the sagittal cervical radiographic metrics demonstrated a loss of lordosis of the original lordosis correction. Here, the lordosis measured −17.6° (vs. −33°), the APL measured −25.4° (vs. −29.3°) and the AHT measured 22.9 mm.

Following the second round of CBP rehabilitation (post-MVC) there was improved neck pain (0–1/10 vs. 3–4/10) and LBP (1–2/10 vs. 4/10). There was a 14% improvement in NDI score (8% vs. 22%). The paraspinal tenderness upon palpation was resolved in the cervical and thoracic spine, there was mild tenderness in the lumbar spinal area. There was full ROM in the cervical and lumbar spine with only mild pain upon lumbar extension (1/10). All orthopedic tests were negative. The CBP rehabilitation directed at increasing the cervical lordosis was again successful, the sagittal cervical metrics showed a 12.3° increase in lordosis (−29.9° vs. −17.6°), a 9.3° increase in APL (−34.7° vs. −25.4°), and a 2 mm reduction in AHT (20.9 mm vs. 22.9 mm).

At the 6.5-month follow-up, after improving the cervical lordosis following the MVC, all the sagittal cervical metrics were maintained; the lordosis was −31.7° (vs. −29.9°), the AHT was 22.5 mm (vs. 20.9 mm), and the APL was −30.3° (vs. −34.7°). The adolescent remained well and scored a 4% on the NDI and an 8% on the ODI.

## DISCUSSION

This case documented the effect of a whiplash event on the cervical spine that had been radiographed 8 months previously. Both rounds of CBP rehabilitation were successful at re-establishing the cervical lordosis, both preceding and following the whiplash event. The lordosis correction was maintained as was the wellness of the patient at a 6.5-month follow-up.

The stability of the lordosis as illustrated in the 6.5-month post-MVC rehabilitation adds support to confirm that the whiplash event caused a straightening of the cervical lordosis; it caused a 15.4° loss of curvature. This is in the range reported by Harrison et al.[11] who found an average of a 10° loss of cervical lordosis in 41 patients having a pre- and post- MVC imaging within 1-month of the collision event.

If the results of this case and the series by Harrison et al.[11] can be verified, and patients involved in whiplash events experience a loss of cervical curvature, it would be deemed essential to: 1) perform routine radiological imaging to quantify the misalignment; 2) apply rehabilitation methods to increase and re-establish the cervical lordosis.

First, as mentioned, comprehensive assessment of the cervical lordosis can only be done by routine X-rays to the region and quantification of important spinal parameters including global lordosis, AHT etc[6]. There are however, hesitancies to expose patients to radiation which are outdated concerns, because X-rays do not provide a high enough exposure of radiation to cause harm[26–32]. Further, no other assessment methods (e.g. sagittal visual posture, external spine measures, palpation, etc.) can accurately quantify the alignment of the sagittal cervical spine and therefore, X-ray is the only clinically efficient and valid assessment tool[32–34].

Second, the diagnosis of cervical spine hypolordosis/kyphosis requires specific rehabilitation methods that can improve its structural alignment. CBP methods that include cervical extension traction as was performed in this report has an abundance of published evidence[4, 5]. In fact, controlled trials have demonstrated that routine cervical spine lordosis improvement can be achieved in 10–12 weeks of treatment[4, 35–37]. It is also important to consider that common physiotherapeutic methods do not, on average, or efficiently, increase the cervical lordosis; thus, specific extension traction methods must be integrated into a rehabilitation program in the treatment of MVC patients to have successful re-establishment of the cervical lordosis as has been previously demonstrated in MVC patients[13–17].

A main argument for the need for lordosis increasing methods to be employed in MVC patients diagnosed with cervical spine hypolordosis is the fact that patients suffering long-term consequences of whiplash have been found to be those patients whom have a straightened and/or a reversed cervical spine[38, 39]. Long-term adverse consequences to loss of lordosis following MVC include degenerative changes, pain and disability. Since it is understood that loss of lordosis leads to a degenerative cascade[40–42], then re-establishing the lordosis when diagnosed as abnormal should not only aid in the recovery from the injury but prevent future suffering from untoward degenerative spinal changes.

The limitations to this case is that it is a single subject case report and therefore not a controlled study design. Strengths include the short duration of X-ray evidence of lordosis to the post-MVC X-ray showing loss of lordosis being 8 months. The maintenance of the cervical lordosis following the post-MVC rehabilitation demonstrates that without trauma, the cervical lordosis remains stable over time as been shown by others[43, 44]. Larger case series, case controls, and randomized trials are needed to fully document the effects of restoring abnormal sagittal cervical alignment for the improvement in both acute and chronic MVC injured cases.

## *Conflict of interest*

Dr. Paul Oakley (PAO) is a paid consultant for CBP NonProfit, Inc.; Dr. Deed Harrison (DEH) teaches chiropractic rehabilitation methods and sells products to physicians for patient care as used in this manuscript.

## REFERENCES


1) Fortner MO, Woodham TJ, Oakley PA, et al.: Is the cervical lordosis a key biomechanical biomarker in cervicogenic headache?: a Chiropractic Biophysics® case report with follow-up. J Phys Ther Sci, 2022, 34: 167–171. [Medline] [CrossRef]
2) Gerstin G, Oakley PA, Harrison DE: The treatment of dizziness by improving cervical lordosis: a Chiropractic BioPhysics® case report. J Phys Ther Sci, 2020, 32: 864–868. [Medline] [CrossRef]
3) Mahmoud NF, Hassan KA, Abdelmajeed SF, et al.: The relationship between forward head posture and neck pain: a systematic review and meta-analysis. Curr Rev Musculoskelet Med, 2019, 12: 562–577. [Medline] [CrossRef]
4) Oakley PA, Ehsani NN, Moustafa IM, et al.: Restoring cervical lordosis by cervical extension traction methods in the treatment of cervical spine disorders: a systematic review of controlled trials. J Phys Ther Sci, 2021, 33: 784–794. [Medline] [CrossRef]
5) Oakley PA, Kallan SZ, Harrison DE: Structural rehabilitation of the cervical lordosis and forward head posture: a selective review of Chiropractic BioPhysics® case reports. J Phys Ther Sci, 2022, 34: 759–771. [Medline] [CrossRef]
6) Ling FP, Chevillotte T, Leglise A, et al.: Which parameters are relevant in sagittal balance analysis of the cervical spine? A literature review. Eur Spine J, 2018, 27: 8–15. [Medline] [CrossRef]
7) Patwardhan AG, Khayatzadeh S, Havey RM, et al.: Cervical sagittal balance: a biomechanical perspective can help clinical practice. Eur Spine J, 2018, 27: 25–38. [Medline] [CrossRef]
8) Spitzer WO, Skovron ML, Salmi LR, et al.: Scientific monograph of the Quebec Task Force on whiplash-associated disorders: redefining “whiplash” and its management. Spine, 1995, 20: 1S–73S. [Medline]
9) Panjabi MM, Pearson AM, Ito S, et al.: Cervical spine curvature during simulated whiplash. Clin Biomech (Bristol, Avon), 2004, 19: 1–9. [Medline] [CrossRef]
10) Grauer JN, Panjabi MM, Cholewicki J, et al.: Whiplash produces an s-shaped curvature of the neck with hyperextension at lower levels. Spine, 1997, 22: 2489–2494. [Medline] [CrossRef]
11) Harrison DE, Harrison DD, Katz E, et al.: Abnormal static sagittal cervical curvatures following motor vehicle collisions: a retrospective case control of 41 subjects exposed to a motor vehicle collision. J Chiropr Educ, 2007, 21: 106.
12) Rydman E, Elkan P, Eneqvist T, et al.: The significance of cervical sagittal alignment for nonrecovery after whiplash injury. Spine J, 2020, 20: 1229–1238. [Medline] [CrossRef]
13) Fedorchuk C, Lightstone DF, Comer RD, et al.: Improvements in cervical spinal canal diameter and neck disability following correction of cervical lordosis and cervical spondylolistheses using Chiropractic BioPhysics technique: a case series. J Radiol Case Rep, 2020, 14: 21–37. [Medline]
14) Fortner MO, Oakley PA, Harrison DE: Cervical lordosis restoration for late whiplash syndrome alleviates chronic headaches 13-years after motor vehicle collision: a CBP® case report with a 1-year follow-up. J Contemp Chiro, 2020, 3: 21–27.
15) Fortner MO, Oakley PA, Harrison DE: Cervical extension traction as part of a multimodal rehabilitation program relieves whiplash-associated disorders in a patient having failed previous chiropractic treatment: a CBP® case report. J Phys Ther Sci, 2018, 30: 266–270. [Medline] [CrossRef]
16) Fortner MO, Oakley PA, Harrison DE: Alleviation of posttraumatic dizziness by restoration of the cervical lordosis: a CBP® case study with a one year follow-

up. J Phys Ther Sci, 2018, 30: 730–733. [Medline] [CrossRef]

17) Ferrantelli JR, Harrison DE, Harrison DD, et al.: Conservative treatment of a patient with previously unresponsive whiplash-associated disorders using clinical biomechanics of posture rehabilitation methods. J Manipulative Physiol Ther, 2005, 28: e1–e8. [Medline] [CrossRef]
18) Harrison DE, Harrison DD, Cailliet R, et al.: Cobb method or Harrison posterior tangent method: which to choose for lateral cervical radiographic analysis. Spine, 2000, 25: 2072–2078. [Medline] [CrossRef]
19) Harrison DE, Holland B, Harrison DD, et al.: Further reliability analysis of the Harrison radiographic line-drawing methods: crossed ICCs for lateral posterior tangents and modified Risser-Ferguson method on AP views. J Manipulative Physiol Ther, 2002, 25: 93–98. [Medline] [CrossRef]
20) Harrison DD, Janik TJ, Harrison GR, et al.: Chiropractic biophysics technique: a linear algebra approach to posture in chiropractic. J Manipulative Physiol Ther, 1996, 19: 525–535. [Medline]
21) Oakley PA, Harrison DD, Harrison DE, et al.: Evidence-based protocol for structural rehabilitation of the spine and posture: review of clinical biomechanics of posture (CBP) publications. J Can Chiropr Assoc, 2005, 49: 270–296. [Medline]
22) Harrison DE, Harrison DD, Haas JW: Structural rehabilitation of the cervical spine. Evanston: Harrison CBP® Seminars, Inc., 2002.
23) Oakley PA, Moustafa IM, Harrison DE: Restoration of cervical and lumbar lordosis: CBP® methods overview. In: Bettany-Saltikov J, (ed.) Spinal deformities in adolescents, adults and older adults. London: IntechOpen Publishers, 2019, pp 1–19.
24) Harrison DE, Oakley PA: An introduction to Chiropractic BioPhysics® (CBP®) technique: a full spine rehabilitation approach to reducing spine deformities. In: M. Bernardo-Filho (ed.) Complementary Therapies. London: IntechOpen Publishers, May 19, 2022, pp 1–35.
25) Harrison DE, Harrison DD, Betz JJ, et al.: Increasing the cervical lordosis with chiropractic biophysics seated combined extension-compression and transverse load cervical traction with cervical manipulation: nonrandomized clinical control trial. J Manipulative Physiol Ther, 2003, 26: 139–151. [Medline] [CrossRef]
26) Oakley PA, Harrison DE: Radiophobic fear-mongering, misappropriation of medical references and dismissing relevant data forms the false stance for advocating against the use of routine and repeat radiography in chiropractic and manual therapy. Dose Response, 2021, 19: 1559325820984626. [Medline] [CrossRef]
27) Oakley PA, Harrison DE: Are continued efforts to reduce radiation exposures from X-rays warranted? Dose Response, 2021, 19: 1559325821995653. [Medline] [CrossRef]
28) Oakley PA, Harrison DE: Death of the ALARA radiation protection principle as used in the medical sector. Dose Response, 2020, 18: 1559325820921641. [Medline] [CrossRef]
29) Oakley PA, Harrison DE: X-ray hesitancy: patients' radiophobic concerns over medical x-rays. Dose Response, 2020, 18: 1559325820959542. [Medline] [CrossRef]
30) Oakley PA, Navid Ehsani N, Harrison DE: 5 Reasons why scoliosis X-rays are not harmful. Dose Response, 2020, 18: 1559325820957797. [Medline] [CrossRef]
31) Oakley PA, Harrison DE: Radiophobia: 7 reasons why radiography used in spine and posture rehabilitation should not be feared or avoided. Dose Response, 2018, 16: 1559325818781445. [Medline] [CrossRef]
32) Oakley PA, Cuttler JM, Harrison DE: X-ray imaging is essential for contemporary chiropractic and manual therapy spinal rehabilitation: radiography increases benefits and reduces risks. Dose Response, 2018, 16: 1559325818781437. [Medline]
33) Harrison DE, Haas JW, Cailliet R, et al.: Concurrent validity of flexicurve instrument measurements: sagittal skin contour of the cervical spine compared with lateral cervical radiographic measurements. J Manipulative Physiol Ther, 2005, 28: 597–603. [Medline] [CrossRef]
34) Daffin L, Stuelcken M, Sayers M: Internal and external sagittal craniovertebral alignment: a comparison between radiological and photogrammetric approaches in asymptomatic participants. Musculoskelet Sci Pract, 2019, 43: 12–17. [Medline] [CrossRef]
35) Moustafa IM, Diab AA, Hegazy F, et al.: Demonstration of central conduction time and neuroplastic changes after cervical lordosis rehabilitation in asymptomatic subjects: a randomized, placebo-controlled trial. Sci Rep, 2021, 11: 15379. [Medline] [CrossRef]
36) Moustafa I, Youssef AS, Ahbouch A, et al.: Demonstration of autonomic nervous function and cervical sensorimotor control after cervical lordosis rehabilitation: a randomized controlled trial. J Athl Train, 2021, 56: 427–436. [Medline] [CrossRef]
37) Moustafa IM, Diab A, Shousha T, et al.: Does restoration of sagittal cervical alignment improve cervicogenic headache pain and disability: a 2-year pilot randomized controlled trial. Heliyon, 2021, 7: e06467. [Medline] [CrossRef]
38) Norris SH, Watt I: The prognosis of neck injuries resulting from rear-end vehicle collisions. J Bone Joint Surg Br, 1983, 65: 608–611. [Medline] [CrossRef]
39) Hohl M: Soft-tissue injuries of the neck in automobile accidents. Factors influencing prognosis. J Bone Joint Surg Am, 1974, 56: 1675–1682. [Medline] [CrossRef]
40) Oakley P, Sanchez L, Harrison D: Medical radiologists may not consider the cervical lordosis in radiology reports: a comparison of subjective qualitative assessment versus objective quantitative mensuration in 100 consecutive patients at one medical imaging center. J Contemp Chiro, 2021, 4: 17–25.
41) Harrison DE, Harrison DD, Janik TJ, et al.: Comparison of axial and flexural stresses in lordosis and three buckled configurations of the cervical spine. Clin Biomech (Bristol, Avon), 2001, 16: 276–284. [Medline] [CrossRef]
42) Harrison DE, Jones EW, Janik TJ, et al.: Evaluation of axial and flexural stresses in the vertebral body cortex and trabecular bone in lordosis and two sagittal cervical translation configurations with an elliptical shell model. J Manipulative Physiol Ther, 2002, 25: 391–401. [Medline] [CrossRef]
43) Gore DR: Roentgenographic findings in the cervical spine in asymptomatic persons: a ten-year follow-up. Spine, 2001, 26: 2463–2466. [Medline] [CrossRef]
44) Harrison DE, Harrison DD, Colloca CJ, et al.: Repeatability over time of posture, radiograph positioning, and radiograph line drawing: an analysis of six control groups. J Manipulative Physiol Ther, 2003, 26: 87–98. [Medline] [CrossRef]