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Non-surgical Reduction of Thoracic Hyper-kyphosis in a 24-year Old Music Teacher Utilizing Chiropractic BioPhysics® Technique

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Authors' contributions

This work was carried out in collaboration between all authors. Author JOJ treated the patient and collected the data. Authors JOJ and PAO compiled the first draft. Authors DEH and CJC contributed to further drafts, literature reviews. Authors JOJ, PAO and DEH read and approved the final manuscript.

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Case Study

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ABSTRACT

Background: Thoracic hyper-kyphosis is a postural deviation that is associated with morbidity and mortality. There is limited evidence for the non-surgical reduction treatment for this condition.
Objective: To describe the successful case of conservative reduction in thoracic hyper-kyphosis utilizing thoracic extension traction methods as performed in Chiropractic BioPhysics (CBP®) Technique.
Clinical Features: On May 8, 2009 a 24-year old female music teacher reported to a spine clinic in Las Vegas seeking treatment while suffering from neck, mid, and low back pain as well as headaches. The major postural condition was determined to be a hyper-kyphotic thoracic spine

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with concomitant posterior thoracic translation.
Intervention and Outcome: This patient was treated with full CBP® protocol with the unique application of thoracic extension traction. Although the treatment was interrupted by her involvement in a motor vehicle collision, a clinically significant reduction in her kyphosis occurred bringing her spine to within normal limits. She had simultaneous improvements in her clinical symptoms, neurologic and orthopedic tests.
Discussion: Traditional conservative treatment options for thoracic hyper-kyphosis have included exercise, manual therapy, spinal orthosis, 'practiced normal posture,' and more recently, taping. All of these procedures, however, have been criticized because despite these methods as showing promise for improving health outcomes in patients with hyper-kyphosis, the trials used to evaluate them have been "small in scale, and most short in duration." Since this deformity is associated with osteoporosis and worsening of kyphosis it is well advised to treat this condition earlier rather than later.
Conclusion: Although traditional approaches to non-surgical treatment for thoracic hyper-kyphosis has weak supportive evidence, we propose extension traction for this condition will prove to be an effective treatment option.

Keywords: Thoracic spine; posture; hyper-kyphosis; chiropractic; extension traction.

1. INTRODUCTION

Abnormal posture is associated with musculoskeletal symptoms and decreased quality of life [1-4]. Increased load sharing upon vertebral segments is related to postural stresses that are found to accelerate disc degeneration and spinal pain [5-9]. The kyphotic thoracic spine is located between the more flexible cervical and lumbar lordotic spinal regions, combined with the lack of sound scientific data for the non-surgical management of this spinal region, it comes with unique considerations regarding its treatment [10].

The normal spine is characterized by a thoracic kyphosis of approximately 40° when measured between T2 and T10 spinal levels [11-13]. It has been found to be elliptical in configuration, having its larger curve at the top and becoming straighter as it leads towards the lumbar spine, where it is essentially straight through the thoraco-lumbar spinal region [11]. Its larger curve through the upper thorax inflects at T1 as it leads into a lordosis in the cervical spine [11].

The thorax is also associated with balancing the torso in the sagittal plane, as well it has a correlation and spinal coupling relationship between the lumbar and cervical spinal areas [14,15]. Harrison et al. [14] for example, determined that in posterior translation of the thorax, a concomitant hyper-thoracic curvature emerges with an upper thoracolumbar kyphosis and lower lumbar hyperlordosis. Loder [15] found a simultaneous increased upper thoracic angulation with an increased forward head shifting resulting in an increased cervical lordosis.

Thoracic kyphosis deformity is negatively associated with a number of health-related quality of life measures [16,17]. An increased thoracic kyphosis is associated with spinal pain, compression of internal organs leading to reduced lung capacity [18,19], reduced rib mobility [19], uterine prolapse [20,21], gastric hernia [22], as well as compression fractures [23,24]. Many studies have also verified that hyper-thoracic postures reduce life expectancy and have been proven to cause early death [18,25-30].

For better understanding and treatment of postural disorders, mathematical modeling has been derived in an attempt to reduce excessive load sharing on surgical implants [31-33]. Recently, the human spine has been modeled in each of the cervical, thoracic, and lumbar regions for determination of normal and ideal parameters [34-37]. The thoracic curvature has been modeled as an ellipse [34], where the lower thoracic spine is straight through the thoracolumbar junction and becomes more curved the higher up the thoracic spine. Knowledge of ideal spinal configurations provides important normative data for clinical decision-making and recommendations for objective structural outcomes of patient care [38-41].

There is limited clinical evidence within the chiropractic literature as well as very little evidence of non-surgical alternatives, at large, for

the correction and reduction of the postural pathologic thoracic hyper-kyphosis. This case presents the successful reduction of hyper-kyphotic thoracic posture corresponding with the elimination of spinal pains in a 24-year old female music teacher using Chiropractic BioPhysics (CBP®) technique.

2. CASE REPORT

2.1 Clinical Features

On May 8, 2009 a 24-year old female music teacher reported to a spine clinic in Las Vegas, NV seeking treatment suffering from neck, mid, and low back pain as well as headaches. Informed consent and a medical history were obtained. The patient was right hand dominant, measured 5' 8" in height, and weighed 140 lbs. Her self-reported neck pain frequency was rated as intermittent (50-74% of the time), and scored a 7/10 on the Numerical Rating Scale (NRS). The effect of the patient's condition on her activities of daily living were evaluated with the Neck Disability Index (NDI) questionnaire [42] which was scored at 28% (14/50). This score is associated with a moderate disability that most appreciably also affected her sleep.

The patient also reported having intermittent low back pain rated as a 6/10 (NRS) and scored as a 32% (16/50) on the Revised Oswestry Low Back Pain Disability Questionnaire [43]. Intermittent middle back and scapular regional tightness (6/10) were also chief complaints of the patient. Last, she experienced occasional headaches (5/10) in the frontal region of her head. The patient stated that she experienced full spine tightness and soreness in the mornings.

2.2 Physical Examination

Physical examination revealed a blood pressure taken on the left arm seated auscultation 102/72 and a pulse taken radially on the same arm of 68 beats per minute. Neurological evaluation was unremarkable as well as spinal orthopedic examination for standard tests. Visual postural analysis was conducted using Chiropractic Biophysics (CBP) Technique derived using the Cartesian coordinate system that has been described elsewhere [40,41]. Postural examination revealed a posteriorly translated thoracic spine ($-T_Z^T$) that appeared hyper-kyphotic as well as forward head posture ($+T_Z^H$). Palpation revealed tightness, loss of segmental motion and fixation at C4-7, T3-8 and L2-4, bilaterally.

Cervical range of motion examination revealed a mild to moderate reduction in all directions without reproduction of pain or tightness. Thoraco-lumbar ROM, however, revealed a mild to moderate loss of motion in all directions with the patient reporting tightness in bilateral bending. Radiographic examination was undertaken including A-P and lateral sectional X-rays of the cervical, thoracic and lumbo-pelvic regions. Radiographic analysis was negative for osteopathology or soft-tissue abnormalities.

Biomechanical radiographic analysis was conducted utilizing digitization with PostureRay® Software (Posture Co. Inc., Trinity, FL). Absolute and relative rotation angles and thoracic spine z-axis (A-P) displacements were obtained from digitization of the lateral thoracic spine radiographic analysis. The main postural deviation was thoracic hyper-kyphosis demonstrating excess curvature as measured from T2-T11 of 64.9° (41.2° normal [11]) as well as a posteriorly translated thoracic cage (11 mm) (Fig. 1a).

Other radiographic features were cervical spine hyperlordosis (51.9° vs. 42° normal), forward head translation (23.8 mm), and an atlas plane line of 25.2°. Lumbar spine lordosis measured 37.5° with a sacral base angle of 41.2°. AP radiographs showed a 10 mm right translation of the head, and a 6.6 mm translation of the thorax to the left. The patient also had an anatomical leg length inequality (LLI) on the left of 18 mm.

3. INTERVENTION AND OUTCOME

The patient started care on May 19, 2009. Initially the patient was treated at a frequency of 3-4 times per week, receiving five treatments aimed at reducing her pain and increasing her flexibility. Initial acute care protocol techniques included full spine diversified spinal manipulation to the cervical, thoracic, and lumbar regions. In addition, axial cervical spine/upper thoracic spine distraction traction was performed with 20lbs for 10 minutes per session to unload the spinal discs and facet joints. The patient also received intersegmental traction with simultaneous vibration, interferential current and cryotherapy.

The intersegmental traction was performed on a Thomas Table with vibration and mechanized

rollers that gently pushed P-A into the patients spine while the patient was lying supine on the intersegmental table, with ice packs on the table between the table top and the patient's spine for a 10 minute duration, while having interferential electrical stimulation. The intent of this treatment methodology is to simultaneously reduce pain and inflammation while mobilizing the affected region being treated.

On June 1, 2009, the patient started CBP® technique [40,41] spinal rehabilitative measures including mirror image® postural adjusting using a drop table and with use of the Impulse® hand-held adjusting instrument (Neuromechanical Innovations, Chandler, AZ). Spinal extension traction to reduce the thoracic hyper-kyphosis was applied using the Universal Tractioning System (UTS-Universal Tractioning Systems, Inc. Las Vegas, NV) (Fig. 2). Treatments continued at 3-4 times per week. Traction time started at 3 minutes and progressively increased to 15 minutes over six consecutive sessions according to patient tolerance.

On each visit of rehabilitative care, the patient also performed 3 sets of 15 repetitions of mirror image head retraction exercises, while also pulling the pelvis posterior to the wall to extend the thoracic spine. The patient also performed thoraco-lumbar anterior and posterior core stability exercises on a Theraball®, performing 3 sets of 15 repetitions. Following this therapeutic intervention, cryotherapy was applied to the targeted exercised regions simultaneously during intersegmental traction for ten minutes to relax the muscles and discourage inflammatory response after therapy.

The patient also received instructions for home therapy including rest, ice, mirror-image exercises of the thoracic spine on a theraball with resistance against gravity, 3 sets of 15 repetitions, to be performed 3-7 times per week.

After 24 CBP® focused treatments (29 treatments overall), the patient was in a motor vehicle collision on Sept. 17, 2009 and an evaluation and management assessment was performed on Sept. 18, 2009. Her symptoms were exacerbated but were not as severe as when she had first presented (i.e. 4-6/10 NRS).

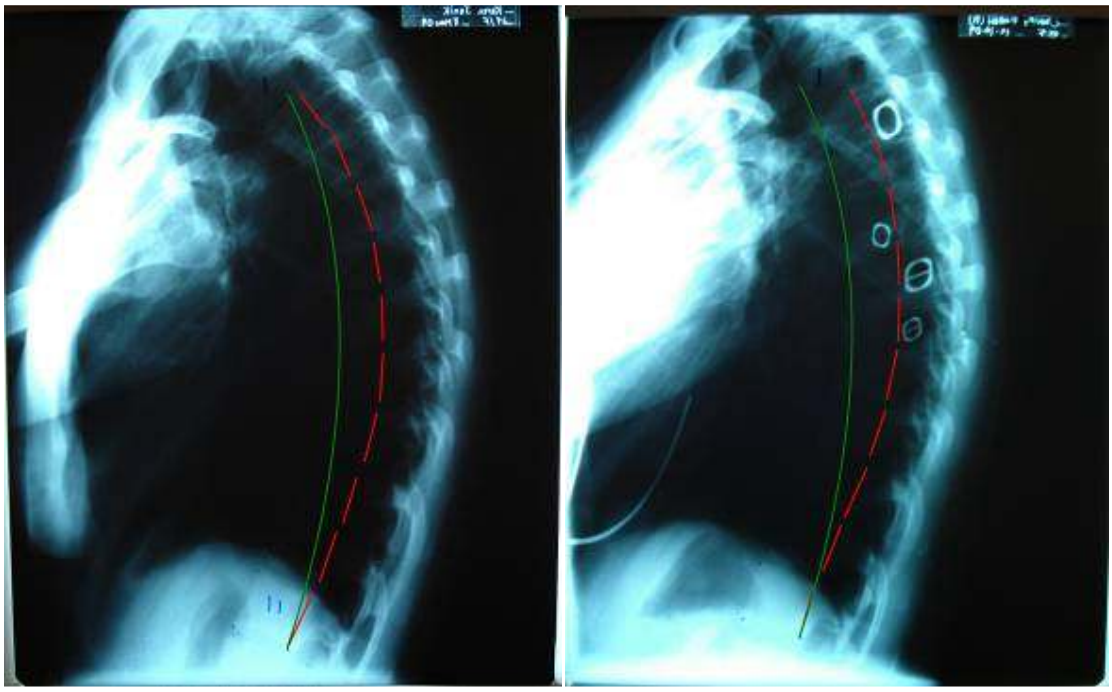

Fig. 1. Initial (Left: 5/8/09) and post (Right: 12/16/09) lateral thoracic radiograph showing reduction of hyper-thoracic kyphosis. Absolute rotation angle T2-11 reduced from 64.9°to 42.2°. Note: Patient still has mild extension of th e thoracic cage

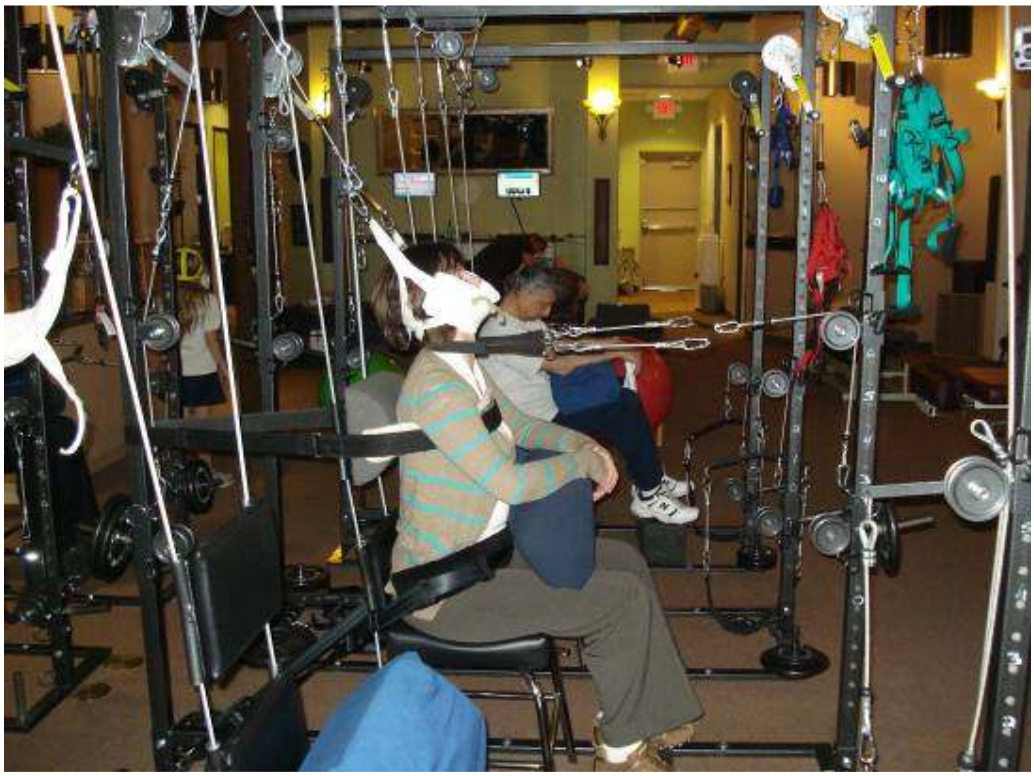

Fig. 2. Patient in mirror-image® thoracic extension traction utilizing a Universal Tractioning System (Universal Tractioning Systems Inc., Las Vegas, NV). The seated patient has holding strap around ASIS while being blocked behind mid thorax with a posterior pull on chin to hyper-extend the cervico-thoracic spine

Repeat radiographs of the thoracic spine demonstrated a lateral curve measuring 52° from T2-T11. The patient resumed acute care treatment protocols on Sept. 19, 2009 and was treated initially, again for symptom relief, as described above for 13 visits until her pain had markedly reduced to the point of rehabilitative tolerance. On Oct. 15, 2009, CBP® technique was again resumed to correct her thoracic hyper-kyphosis, as previously described.

Following 24 additional CBP® focused treatments an assessment was performed on Dec. 16, 2009. She reported only mild discomfort (1/10) for all spinal regions with all other orthopedic tests within normal limits. The lateral thoracic kyphosis measured within normal limits (T2-T11= 42°) (Fig. 1b). At this point the patient was released from corrective care but elected to continue on supportive/maintenance care consisting of two treatments per month in an attempt to maintain the level of improvement achieved. On Sept 2, 2010 after approximately 9-months of supportive care an assessment and x-ray revealed that she had maintained her thoracic curve in normal alignment (41°) and also remained well reporting only very mild and occasional symptomology (1/10 NRS). At the date of this exam she had received a total of 84 treatments over 15.5 months. She elected to further continue supportive care on a two times per month frequency.

4. DISCUSSION

This case demonstrates the resolution of spinal pain concomitant with the reduction of hyper-kyphotic thoracic posture in a 24-year old. Novel in this report is the non-surgical correction of thoracic hyper-kyphosis through conservative rehabilitative chiropractic care using CBP® technique.

Currently, there is no real scientific data on effective non-surgical, conservative treatments for thoracic hyper-kyphosis [10]. The traditional conservative treatment options have included exercise, manual therapy, spinal orthosis,

'practiced normal posture,' and more recently, taping [44,45]. All of these procedures, however, have been criticized, despite these methods showing promise for improving health outcomes in patients with hyper-kyphosis, the trials used to evaluate them have been "small in scale, and most short in duration" [46].

A number of studies have indicated the importance of age-related changes in the thoracic spine and their clinical associations [12,19,47,48].The importance of correcting a thoracic hyperkyphosis cannot be overstated as the severity of thoracic kyphosis has been shown to increase with decreasing bone mineral density [13]. In advanced osteoporosis, compression fractures result in a loss of vertebral height and formation of a kyphotic deformity or 'Dowager's Hump' [49]. This deformity is often associated with severe pain and loss of mobility [50,51]. Further, vertebral deformity models have confirmed that initiation of spinal kyphotic deformity is exacerbated by anterior translation of the upper spinal column [20]. Thus, a hyperkyphotic posture combined with later life osteoporosis creates a vicious cycle of a continually deteriorating posture. These studies and others support the importance of correcting thoracic hyper-kyphosis early, as was accomplished in the current case.

We believe that the application of thoracic extension traction that reverses the stresses in the thoracic spine and the implementation of the 'mirror-image' concept that underpins CBP® Technique, will prove to be a valuable option for treating this condition. It is also noted that with minimal 'supportive' or 'maintenance' treatment, the thoracic spine posture was maintained in normal alignment. Although not yet studied for the thoracic spine, the long-term maintenance of CBP® treatment corrected postures has been found to be relatively stable with little maintenance in the lumbar and cervical spines [52,53].

5. CONCLUSION

Due to limited evidence for effective, non-surgical treatments to treat thoracic hyper-kyphosis, and considering the desirable outcome in this case, we suggest investigation into the effectiveness of thoracic spine extension traction for the treatment of this condition may prove an effective option.

CONSENT

All authors declare that 'written informed consent was obtained from the patient for publication of this case report and accompanying images.

ETHICAL APPROVAL

Not applicable other than informed consent was obtained from the patient related to information reported herein.

COMPETING INTERESTS

Authors have declared the following conflicts of interest:

JOJ manufactures and sells the full spine, in office, traction system used in this case report, to health care providers, called, Universal Tractioning Systems® or UTS®. UTS-Universal Tractioning Systems, Inc. Las Vegas, NV.

CJC is the manufacturer of Impulse® hand-held adjusting instruments (Neuromechanical Innovations, Chandler, AZ).

DEH is the President and CEO of Chiropractic BioPhysics (CBP Technique) seminars. He lectures and trains Chiropractors in the details of CBP Technique in continuing education conferences.

REFERENCES

1. Araujo F, Lucas R, Alegrete N, Azevedo A, Barros H. Individual and contextual characteristics as determinants of sagittal standing posture: A population-based study of adults. Spine J. 2014;30(14):10.
2. Dolphens M, Cagnie B, Coorevits P, Vleeming A, Danneels L. Classification system of the normal variation in sagittal standing plane alignment: A study among young adolescent boys. Spine. 2013;38(16):E1003-E1012.
3. Dolphens M, Cagnie B, Coorevits P, Vanderstraeten G, Cardon G, D'hooge R, et al. Sagittal standing posture and its association with spinal pain: A school-based epidemiological study of 1196 Flemish adolescents before age at peak height velocity. Spine. 2012;37(19):1657-66.
4. Troyanovich SJ, Harrison DE, Harrison DD. Structural rehabilitation of the spine

and posture: Rationale for treatment beyond the resolution of symptoms. J Manipulative Physiol Ther. 1998;21(1):37-50.

5. Adams MA. Biomechanics of back pain. Acupunct Med. 2004;22(4):178-88.
6. Adams MA, Hutton WC. The effect of posture on the role of the apophysial joints in resisting intervertebral compressive forces. J Bone Joint Surg [Br]. 1980;62(3):358-62.
7. Adams MA, Hutton WC. The effect of posture on the lumbar spine. J Bone Joint Surg [Br]. 1985;67(4):625-9.
8. Adams MA, McMillan DW, Green TP, Dolan P. Sustained loading generates stress concentrations in lumbar intervertebral discs. Spine. 1996;21(4):434-8.
9. Bruno AG, Anderson DE, D'Agostino J, Bouxsein ML. The effect of thoracic kyphosis and sagittal plane alignment on vertebral compressive loading. J Bone Miner Res. 2012;27(10):2144-51.
10. De Mauroy JC, et al. 7th SOSORT consensus paper: conservative treatment of idiopathic & Scheuermann's kyphosis. Scoliosis. 2010;5:9.
11. Harrison DE, et al. Can the thoracic kyphosis be modeled with a simple geometric shape? J Spinal Disord Tech. 2002;15:213-220.
12. Betten J. Generalization of nonlinear material laws found in experiments to multi-axial states of stress. European Journal of Mechanics, A/Solids. 1989;8:325-39.
13. Goh S, Price RI, Leedman PJ, Singer KP. Age-independent correlation of optically determined thoracic kyphosis with lumbar spine bone mineral density. J Musculoskel Res. 1999;3:267-74.
14. Harrison DE, Cailliet R, Harrison DD, Janik TJ. How do anterior/posterior translations of the thoracic cage affect the sagittal lumbar spine, pelvic tilt, and thoracic kyphosis? Eur Spine J. 2002;11(3):287-93. Epub 2001 Nov 1.
15. Loder RT. The sagittal profile of the cervical and lumbosacral spine in Scheuermann thoracic kyphosis. J Spinal Disord. 2001;14:226-31.
16. Lonner B, Yoo A, Terran JS, Sponseller P, Samdani A, Betz R, et al. Effect of spinal deformity on adolescent quality of life comparison of operative scheuermann's kyphosis, adolescent idiopathic scoliosis and normal controls. Spine; 2013.(Jan 30: epub ahead of print).
17. Takahasi T, et al. Trunk deformity is associated with a reduction in outdoor activities of daily living and life satisfaction in community-dwelling older people. Osteoporos Int. 2005;16:273-279.
18. Leech JA, et al. Relationship of lung function to severity of osteoporosis in women. Am Rev Respir Dis. 1990;141:68-71.
19. Culham EG, Jimenez HA, King CE. Thoracic kyphosis, rib mobility, and lung volumes in normal women and women with osteoporosis. Spine. 1994;19(11): 1250-5.
20. Mattox TF, et al. Abnormal spinal curvature and its relationship to pelvic organ prolapse. Am J Obstetrics Gynecology. 2000;183:1381-1384.
21. Lind LR, et al. Thoracic kyphosis and the prevalence of advanced uterine prolapse. Ostet Gynecol. 1996;87:605-9.
22. Winans HM. Anemia in the aged. Syndrome of kyphosis, gastric hernia, and anemia. Texas J Med. 1938;34:422-423.
23. Keller TS, Harrison DE, Colloca CJ, Harrison DD, Janik TJ. Prediction of osteoporotic spinal deformity. Spine. 2003;28(5):455-62.
24. Huang MH. Hyperkyphotic posture and risk of future osteoporotic fractures: The Rancho Bernardo Study. J Bone Miner Res. 2006;21:419-423.
25. Kado DM, et al. Vertebral fractures and mortality in older women: A prospective study. Study of Osteoporotic Fractures Research Group. Arch Intern Med 1999;159:1215-1220.
26. Kado DM, et al. Incident vertebral fractures and mortality in older women: A prospective study. Osteoporos Int. 2003;14:589-594.
27. Kado DM, et al. Hyperkyphotic posture predicts mortality in older community-dwelling man and women. A prospective study. J Am Geriatr Soc. 2004;52:1662-1667.
28. Milne JS, Williamson J. A longitudinal study of kyphosis in older people. Age Aging. 1983;12:225-233.

29. Anderson F, Cowan, NR. Survival of healthy older people. Brit J Prev Med. 1976;30:231-232.
30. Cutler WB, et al. Prevalence of kyphosis in a healthy sample of pre- and postmenopausal women. Am J Phys Med Rehabil. 1993;72:219-225.
31. Le Huec JC, Roussouly P. Sagittal spino-pelvic balance is a crucial analysis for normal and degenerative spine. Eur Spine J. 2011;20 Suppl 5:556-7.
32. Le Huec JC, Charosky S, Barrey C, Rigal J, Aunoble S. Sagittal imbalance cascade for simple degenerative spine and consequences: Algorithm of decision for appropriate treatment. Eur Spine J. 2011;20 Suppl 5:699-703.
33. Le Huec JC, Saddiki R, Franke J, Rigal J, Aunoble S. Equilibrium of the human body and the gravity line: the basics. Eur Spine J. 2011;20 Suppl 5:558-63.
    DOI: 10.1007/s00586-011-1939-7.
34. Harrison DD, Harrison DE, Janik TJ, Cailliet R, Haas J. Do alterations in vertebral and disc dimensions affect an elliptical model of thoracic kyphosis? Spine. 2003;1;28(5):463-9.
35. Harrison DD, Cailliet R, Janik TJ, Troyanovich SJ, Harrison DE, Holland B. Elliptical modeling of the sagittal lumbar lordosis and segmental rotation angles as a method to discriminate between normal and low back pain subjects. J Spinal Disord. 1998;11(5):430-9.
36. Janik TJ, Harrison DD, Cailliet R, Troyanovich SJ, Harrison DE. Can the sagittal lumbar curvature be closely approximated by an ellipse? J Orthop Res. 1998;16(6):766-70.
37. Troyanovich SJ, Cailliet R, Janik TJ, Harrison DD, Harrison DE. Radiographic mensuration characteristics of the sagittal lumbar spine from a normal population with a method to synthesize prior studies of lordosis. J Spinal Disord. 1997;10(5):380-6.
38. Harrison DD, Troyanovich SJ, Harrison DE, Janik TJ, Murphy DJ. A normal sagittal spinal configuration: A desirable clinical outcome. J Manipulative Physiol Ther. 1996;19(6):398-405.
39. Harrison DE, Harrison DD, Troyanovich SJ, Harmon S. A normal spinal position: It's time to accept the evidence. J Manipulative Physiol Ther. 2000;23(9):623-44.
40. Harrison DD, Janik TJ, Harrison GR, Troyanovich S, Harrison DE, Harrison SO. Chiropractic biophysics technique: A linear algebra approach to posture in chiropractic. J Manipulative Physiol Ther. 1996;19(8):525-35.
41. Oakley PA, Harrison DD, Harrison DE, Haas JW. 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(4):270-96.
42. Vernon H, Mior S. The neck disability index: a study of reliability and validity. J Manipulative Physiol Ther. 1991;14(7):409-15.
43. Fairbank J. Revised oswestry disability questionnaire. Spine. 2000;25(19):2549-53.
44. Pizzutillo PD. Nonsurgical treatment of kyphosis. Instr Course Lect. 2004;53:485-491.
45. Katzman WB, et al. Age-related hyperkyphosis: It's causes, consequences, and management. J Orthop Sports Phys Ther. 2010;40:352-360.
46. Kado DM. The rehabilitation of hyperkyphotic posture in the elderly. Eur J Phys Rehabil Med. 2009;45:583-93.
47. Goh S, Tan C, Price RI, Edmondston SJ, Song S, Davis S, et al. Influence of age and gender on thoracic vertebral body shape and disc degeneration: An MR investigation of 169 cases. J Anat. 2000;197 Pt 4:647-57.
48. Cortet B, Houvenagel E, Puisieux F, Roches E, Garnier P, Delcambre B. Spinal curvatures and quality of life in women with vertebral fractures secondary to osteoporosis. Spine. 1999;24(18):1921-5.
49. Schmorl G, Junghanns H. The Human Spine in Health and Disease. New York: Grune & Stratton; 1957.
50. Hall SE, Criddle RA, Comito TL, Prince RL. A case-control study of quality of life and functional impairment in women with long-standing vertebral osteoporotic fracture. Osteoporos Int. 1999;9(6):508-15.
51. Lyles KW, Gold DT, Shipp KM, Pieper CF, Martinez S, Mulhausen PL. Association of osteoporotic vertebral compression

fractures with impaired functional status. Am J Med. 1993;94(6):595-601.

52. Harrison DE, Cailliet R, Harrison DD, Janik TJ, Holland B. Changes in sagittal lumbar configuration with a new method of extension traction: nonrandomized clinical controlled trial. Arch Phys Med Rehabil. 2002;83(11):1585-91.

53. Harrison DE, Cailliet R, Harrison DD, Janik TJ, Holland B. A new 3-point bending traction method for restoring cervical lordosis and cervical manipulation: A nonrandomized clinical controlled trial. Arch Phys Med Rehabil. 2002;83(4):447-53.

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