

Association Between Cervical and Thoracic Somatic Dysfunction Among Second-Year Osteopathic Medical Students

Joseph P. Brindise, DO
Kenneth E. Nelson, DO
Robert E. Kappler, DO

From Botsford Hospital in Farmington Hills, Michigan (Dr Brindise), and the Department of Osteopathic Manipulative Medicine at the Midwestern University/Chicago College of Osteopathic Medicine in Downers Grove, Illinois (Drs Nelson and Kappler).

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Address correspondence to Joseph P. Brindise, DO, Botsford Hospital, Office of Medical Education, 28050 Grand River Ave, Farmington Hills, MI 48336-5919.

E-mail:
jbrindise@botsford.org

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Context: The ubiquitous nature of cervical and thoracic somatic dysfunction requires osteopathic physicians to have a strong working knowledge of regional spinal mechanics and their functional and dysfunctional interrelationships.

Objective: To determine whether cervical and thoracic somatic dysfunction occur concomitantly, particularly somatic dysfunction of the occipitoatlantal (OA) and upper thoracic (T1-T4) region of the spine.

Methods: A retrospective analysis of cervical and thoracic somatic dysfunction prevalence diagnosed by faculty in second-year osteopathic medical students was conducted. Somatic dysfunction was defined as a vertebral unit possessing any of the following palpatory characteristics: tissue texture changes, asymmetry of motion and relative position, restriction of motion, or tenderness (ie, TART criteria). For each instance of somatic dysfunction diagnosed, the segmental level identifying the superior segment of the involved vertebral unit was recorded, as well as the spinal region (ie, cervical [OA, atlantoaxial (AA), and C2-C7] or thoracic [T1-T12]). Descriptive analyses, a Pearson χ^2 test, and a regression model using an analysis of variance were performed on the data.

Results: Among 338 students included in the study, the following 5 vertebral segments were found to have the highest prevalence of somatic dysfunction: OA (257 [76.0%]), C3 (257 [76.0%]), T3 (247 [73.1%]), T5 (226 [66.9%]), and T4 (223 [66.0%]). A Pearson χ^2 test of association between the OA vertebral segment and the following segments were found to be statistically significant: AA ($P=.024$), C2 ($P=.032$), and T4 ($P=.045$). An analysis of variance revealed statistical significance between the prevalence of upper cervical (OA, AA, C2) somatic dysfunction and the prevalence of upper thoracic ($P<.001$) and midthoracic (T5-T8) ($P<.001$) somatic dysfunction; the prevalence of lower cervical (C3-C7) ($P=.74$) and lower thoracic (T9-T12) ($P=.085$) somatic dysfunction was not found to be significant.

Conclusion: A statistically significant association between cervical somatic dysfunction and thoracic somatic dysfunction was confirmed. In addition, there was a statistically significant association between dysfunction of the OA and the AA, C2, and T4 vertebral segments. These results suggest that the number of dysfunctional vertebral segments in the upper thoracic and midthoracic spinal regions is directly proportional to the number of dysfunctional segments found in the upper cervical spinal region.

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The tenets of osteopathic medicine state that the human body is a unit and that structure and function are reciprocally interrelated.¹ In other words, mechanical stresses, injury, or asymmetry affecting one part of the body can create compensatory mechanical changes affecting seemingly unrelated other parts of the body. By applying these concepts, osteopathic physicians are able to effectively provide patients with distinct osteopathic treatment that enhances functional status and maintains or restores health.

Somatic dysfunction is defined as “impaired or altered function of related components of the somatic (body framework) system: skeletal, arthrodial and myofascial structures, and their related vascular, lymphatic and neural elements.”² Studies have found that somatic dysfunction of the cervical and thoracic regions of the spine is frequently encountered in clinical practice. For example, Slezynski and Glonek³ reported that somatic dysfunction was most prevalent in the cervical region, followed by the thoracic (ie, T1 to T4) region. In addition, Licciardone et al⁴ reported that somatic dysfunction was most commonly diagnosed in the upper thoracic, midthoracic, and cervical regions. The ubiquitous nature of cervical and thoracic somatic dysfunction requires osteopathic physicians to have a strong working knowledge of regional spinal mechanics and their functional and dysfunctional interrelationships.

Many clinicians and researchers have described and helped define the mechanisms linking cervical somatic dysfunction with thoracic somatic dysfunction. Johnston and colleagues⁵⁻⁸ were some of the first individuals to describe how cervical and thoracic somatic dysfunctions were interrelated and associated with hypertension. They suggested that this relationship is neurophysiologic and influences both the somatic and cardiovascular systems. Payan⁹ and de Groat¹⁰ recognized that nociceptive input from the cervical spinal region produces palpable musculoskeletal changes in the upper thoracic spinal region and ribs, as well as increases sympathetic output from

this area. Similarly, Heinking and Kappler¹¹ reported that substantial suboccipital tissue texture abnormality is usually associated with changes in the ipsilateral upper thoracic and rib angle area, and Richards¹² stated that cervical somatic dysfunction is rarely found without related somatic dysfunction in the upper thoracic area. Richards also stated that T2 to T4 somatic dysfunctions are common, as the sympathetic nerves to the head and neck originate in the upper thoracic region. Others have described cervical and thoracic postural abnormalities as being related through neurologic reflexes.¹³⁻¹⁵

A predominantly muscular, ligamentous, or bony linkage between the cervical and thoracic regions has also been described. Thoracic, shoulder, and low back segmental somatic dysfunction and pain have been identified as potential causative or complicating factors in patients with chronic mechanical neck disorders and pain.¹⁶⁻¹⁹ Additionally, thoracic somatic dysfunction has been described as an important predictor of neck and shoulder pain.^{16,20} Larson²¹ described how the mechanics of the cervical and upper thoracic spinal regions are linked through the attachments of the longus colli muscle. According to Hruby,²² cervical and upper thoracic motions are associated with the interdependent combination of asymmetric vertebral and upper rib shapes and attachments, and their interactions with muscles are responsible for cervical extension and side-bending.

The goal of the present study was to evaluate the association between occipitoatlantal (OA) somatic dysfunction and upper thoracic somatic dysfunction. Although the relationship between the cervical and thoracic spinal regions has been previously demonstrated in clinical studies, the present study is the first to our knowledge to examine the specific relationship between somatic dysfunction of the OA and upper thoracic vertebral segments. We hypothesized that there would be a statistically significant association between OA somatic dysfunction and upper thoracic somatic dysfunction.

Methods

We retrospectively reviewed data on the prevalence of diagnosed cervical and thoracic somatic dysfunction in second-year osteopathic medical students at the Midwestern University/Chicago College of Osteopathic Medicine (MWU/CCOM) in Downers Grove, Illinois. The data reviewed and analyzed were collected from skills testing examinations that took place during academic years 2008-2009 and 2009-2010. The protocol for the present study was reviewed and approved by the Midwestern University Institutional Review Board. The board determined the study to be exempt from requiring informed consent.

The prevalence data were collected from skills testing examinations that are required to be successfully completed at the end of the second academic year by all osteopathic medical students before they commence predoctoral clinical training. All MWU/CCOM second-year osteopathic medical students who participated in the examinations during the study period were included in the study. No participating students were excluded from the study. To maintain student confidentiality, all of the students' names and identifying information were removed from the written examination records. Each written examination record was then characterized and identified by a numerical code.

For the examination, vertebral segments in the cervical and thoracic spinal regions of each student were screened for somatic dysfunction. Somatic dysfunction was defined as a vertebral unit possessing any of the following palpatory characteristics: tissue texture changes, asymmetry of motion and relative position, restriction of motion, or tenderness (ie, TART criteria).² For each instance of somatic dysfunction diagnosed, the segmental level identifying the superior segment of the involved vertebral unit was recorded, as well as the spinal region (ie, cervical or thoracic). Ten members of the teaching faculty, including licensed osteopathic physicians and osteopathic manipulative medicine teaching fellows, from the MWU/CCOM Osteopathic Manipula-

tive Medicine Department performed the diagnostic examinations. No consensus training occurred.

Data collected from the written examinations were transferred to a Microsoft Excel spreadsheet for management and then to SPSS statistical software (version 18.0; SPSS Inc) for analysis. *P* values less than .05 were considered statistically significant. Descriptive analyses, a Pearson χ^2 test, and a regression model using an analysis of variance were performed. Descriptive statistics were compiled for the prevalence of somatic dysfunction at a given spinal level or in a given spinal region. The Pearson χ^2 test was used to examine associations between OA somatic dysfunction and segmental cervical or thoracic somatic dysfunction. An analysis of variance was used to examine the prevalence of somatic dysfunction for given spinal regions, specifically the upper cervical (OA, AA [atlantoaxial], C2) and the upper thoracic (T1-T4), midthoracic (T5-T8), and lower thoracic (T9-T12) regions of the spine.

Results

A total of 338 MWU/CCOM second-year osteopathic medical students were included in the study. Of the 6760 vertebral segments examined, 3329 (49.2%) were found to have diagnosed somatic dysfunction: 1452 (43.6%) in the cervical spinal region and 1877 (56.4%) in the thoracic spinal region (*Table 1*).

Among all students, the 5 vertebral segments with the highest prevalence of somatic dysfunction were OA (257 [76.0%]), C3 (257 [76.0%]), T3 (247 [73.1%]), T5 (226 [66.9%]), and T4 (223 [66.0%]). Among the 257 students with identified OA somatic dysfunction, the 5 vertebral segments with the highest prevalence were C3 (194 [75.5%]), T3 (193 [75.1%]), T4 (177 [68.9%]), T5 (175 [68.1%]), and C4 (153 [59.5%]). Among the 81 students who did not have demonstrable OA somatic dysfunction, the 5 vertebral segments with the highest prevalence were C3 (63 [77.8%]), T3 (54 [66.7%]), C4 (53 [65.4%]), T5 (51 [63.0%]), and

Table 1.
Cervical and Thoracic Spinal Segments
With Somatic Dysfunction in Second-Year
Osteopathic Medical Students

Spinal Region	Spinal Segments, No. (%) (N=3329)
Cervical	
Upper (OA, AA, C2)	625 (43.0)
Lower (C3-C7)	827 (57.0)
Total	1452 (100.0)
Thoracic	
Upper (T1-T4)	719 (38.3)
Mid (T5-T8)	719 (38.3)
Lower (T9-T12)	439 (23.4)
Total	1877 (100.0)

Abbreviations: AA, atlantoaxial; OA, occipitoatlantal.

T4 (46 [56.8%]). A Pearson χ^2 test revealed associations between somatic dysfunction of the OA vertebral segment and somatic dysfunction of the following segments to be statistically significant: AA ($P=.024$), C2 ($P=.032$), and T4 ($P=.045$) (Table 2 and Figure).

The mean number of vertebrae with somatic dysfunction among the 8 cervical and the 12 thoracic vertebral units per student was 4.3 and 5.6, respectively. The mean number of vertebrae with somatic dysfunction in particular spinal regions per individual student was as follows: upper cervical, 1.8; lower cervical, 2.4; upper thoracic, 2.1; midthoracic, 2.1; and lower thoracic, 1.3. An analysis of variance revealed statistical significance between the mean number of vertebrae with somatic dysfunction in the upper cervical region with respect to the upper thoracic region ($P<.001$) and midthoracic region ($P<.001$); the mean number of vertebrae with somatic dysfunction in the lower cervical ($P=.74$) and lower thoracic ($P=.085$) regions was not found to be statistically significant (Table 3).

Comment

The present study found that the prevalence of somatic dysfunction was highest in the cervical, upper thoracic, and midthoracic regions of the spine. There was a lower prevalence of somatic dysfunction diagnosed in the lower thoracic region. These findings are consistent with previous epidemiologic studies of somatic dysfunction prevalence.^{3,4}

The understanding that somatic dysfunction in the OA region is associated with somatic dysfunction in the AA and the axial-third cervical vertebral units was previously described by Fryette.²³ Fryette stated that these 3 vertebral units—the OA, the AA, and the axis on the third cervical vertebra—lock and unlock as a unit on the basis of their bony topography and their capsular and ligamentous attachments. More recently, Rudolfsson et al²⁴ studied range of motion in the upper and lower cervical spinal regions of individuals with chronic neck pain and found that range of motion was more limited for the upper than for the lower cervical levels. They also suggested that a 3-segment model gives more information than a 2-segment model in characterizing range of motion impairments. Authors of both studies^{23,24} suggest the importance of considering the spine as a whole when dealing with upper cervical somatic dysfunction. Fryette²³ further stated the most common dysfunction of the occiput-atlas-axis articulations is likely to be a compensation for conditions lower in the spine because the head always tends to adjust itself to the line of gravity. These clinical observations and biomechanical assessments are in agreement with the findings that segmental OA somatic dysfunction has a statistically significant association with AA and axial-third cervical vertebra somatic dysfunction. Furthermore, it supports the notion that upper thoracic and midthoracic somatic dysfunction is directly associated with upper cervical somatic dysfunction.

As previously stated, several authors have suggested that the linkage between cervical somatic dysfunction and thoracic somatic dysfunction is mediated by the

Table 2.
Prevalence of Somatic Dysfunction in Cervical and Thoracic Spinal Segments
in Second-Year Osteopathic Medical Students With and Without OA Somatic Dysfunction

Spinal Segment	Students, No (%)			P Value
	All (N=338)	With OA Somatic Dysfunction (n=257)	Without OA Somatic Dysfunction (n=81)	
Upper Cervical				
OA	257 (76.0)	257	81	NA
AA	187 (55.3)	151 (58.8)	36 (44.4)	.024
C2	181 (53.6)	146 (56.8)	35 (43.2)	.032
Lower Cervical				
C3	257 (76.0)	194 (75.5)	63 (77.8)	.67
C4	206 (60.9)	153 (59.5)	53 (65.4)	.34
C5	189 (55.9)	149 (58.0)	40 (49.4)	.17
C6	124 (36.7)	101 (39.3)	23 (28.4)	.076
C7	51 (15.1)	38 (14.8)	13 (16.0)	.78
Upper Thoracic				
T1	61 (18.0)	51 (19.8)	10 (12.3)	.13
T2	188 (55.6)	147 (57.2)	41 (50.6)	.30
T3	247 (73.1)	193 (75.1)	54 (66.7)	.14
T4	223 (66.0)	177 (68.9)	46 (56.8)	.045
Midthoracic				
T5	226 (66.9)	175 (68.1)	51 (63.0)	.39
T6	171 (50.6)	128 (49.8)	43 (53.1)	.61
T7	192 (56.8)	147 (57.2)	45 (55.6)	.80
T8	130 (38.5)	105 (40.9)	25 (30.9)	.11
Lower Thoracic				
T9	128 (37.9)	94 (36.6)	34 (42.0)	.38
T10	128 (37.9)	102 (39.7)	26 (32.1)	.22
T11	97 (28.7)	80 (31.1)	17 (21.0)	.079
T12	86 (25.4)	71 (27.6)	15 (18.5)	.10

Abbreviations: AA, atlantoaxial; NA, not applicable; OA, occipitoatlantal.

sympathetic nervous system.^{9-12,22,25} In the cervical sympathetic nervous system, the preganglionic autonomic fibers originate in the intermediolateral gray column of

spinal cord segments T1 through T5. Additionally, nociceptive afferent fibers from the cervical region of the spine travel with the sympathetic nerves and synapse in

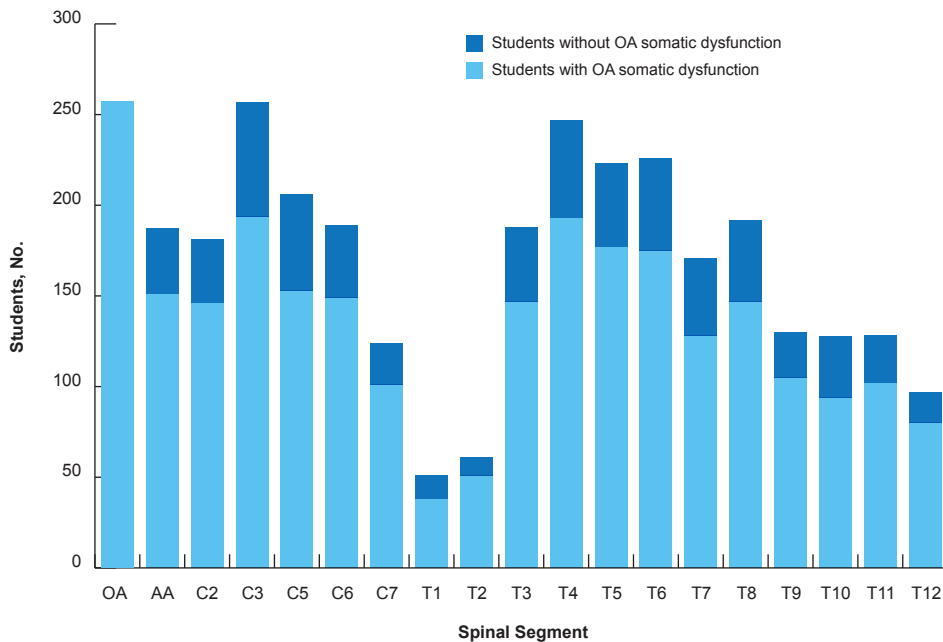


Figure.

Students with somatic dysfunction in the cervical and thoracic spinal regions by spinal segment (N = 338).
 Abbreviations: AA, atlantoaxial; OA, occipitoatlantal.

the upper thoracic spinal cord. Thus, nociceptive input from the cervical region of the spine reflexively produces palpable musculoskeletal changes in the upper thoracic region of the spine and the ribs.^{12,13} Furthermore, sympathetic nerve supply to striated muscles alters muscle tone and contractile forces.¹⁹ Kappler and Ramey²⁵ state that somatic dysfunction in the upper thoracic spinal region, cervicothoracic junction, and cranium can result in increased levels of sympathetic tone. These authors also note an association of the increased sympathetic tone with increased muscle tone, vasoconstriction, and facilitation of afferent pain signals. The facilitation, in concert with the reduction in blood supply to the muscles of the upper back, neck, and head, causes an increase in muscle tenderness and sensitivity to pain. Pain felt locally in the upper thoracic or midthoracic spinal region may originate either from the local thoracic joints or be referred from the cervical joints.^{26,27} Arana et al²⁸ found that correlations of degen-

erative thoracic disk contour changes at the levels of C7 through T1, T1 through T2, T2 through T3, and T3 through T4 were statistically significant in patients with cervical pain. These anatomical relationships further substantiate the findings that OA somatic dysfunction correlates with upper thoracic somatic dysfunction.

Myofascial continuity connects cervical somatic dysfunction with thoracic somatic dysfunction by means of muscular, ligamentous, and bony linkages. The concept of myofascial continuity is exemplified by the fact that muscular and ligamentous structures that attach to or span multiple joints exert their actions onto those joints and areas of the body.²⁹ Magoun³⁰ suggests that the fascial connections below and the 3 dozen or more muscles that attach to the cranial base can affect the occiput and thus alter its articular contacts. The coupling of cervical and upper thoracic spinal mechanics has been attributed to the longus colli muscle, as it attaches to the anterior surface of the vertebral column, between the atlas and the

third thoracic vertebra.^{21,31} It has been suggested that asymmetrical vertebral and upper rib shapes and attachments and their interaction with the cervical musculature can be responsible for the association between cervical and thoracic somatic dysfunction. Specifically, the splenius musculature has been identified as a responsible agent because the splenius capitis muscle attaches inferiorly to the upper 3 or 4 thoracic vertebrae, while the splenius cervicis muscle attaches inferiorly to the third through the sixth thoracic vertebrae.^{22,31} The nuchal ligament may also connect cervical somatic dysfunction and thoracic somatic dysfunction because it extends from the external occipital protuberance to the spinous process of the seventh cervical vertebra. Additionally, the nuchal ligament is composed from the aponeuroses of the trapezius, rhomboideus minor, serratus posterior superior, and splenius capitis muscles.³²

The primary limitation of the current study was the use of second-year osteopathic medical students as the study population. In our experience, medical students tend to be young, healthy, and generally asymptomatic. For the current study's topic—cervical and thoracic somatic dysfunction—it would have been more advantageous to study ambulatory patients in the clinical setting with cervical or thoracic spine symptomatology.

Another limitation of the current study was that the prevalence data were retrospectively collected from a formal assessment of osteopathic medical students' manipulative medicine skills. During this formal assessment, the teaching faculty were permitted to act autonomously and employ their unique diagnostic methods. Autonomous examiners can have poor interexaminer reliability.³³ To improve interexaminer reliability, future studies should either use a single examiner or include consensus training of examiners.³⁴⁻³⁷ The present study's retrospective design prohibited the incorporation of consensus training into the protocol. Additionally, this study design precluded the ability to collect, analyze, and comment on the ipsilateral relationship of cervical and thoracic dysfunctional mechanics because of the recording format of the student examination.

Table 3.
Mean Number of Vertebral Segments With Somatic Dysfunction in the Cervical and Thoracic Spinal Regions per Student (N=338)

Spinal Region	Mean	P Value
Cervical		
Upper (OA, AA, C2)	1.8	NA
Lower (C3-C7)	2.4	.74
Total	4.3	NA
Thoracic		
Upper (T1-T4)	2.1	<.001
Mid (T5-T8)	2.1	<.001
Lower (T9-T12)	1.3	.085
Total	5.6	NA

Abbreviations: AA, atlantoaxial; NA, not applicable; OA, occipitoatlantal.

The goal of the current line of research is to better understand the functional relationships between the cervical and thoracic regions of the spine. The current study was designed to identify and statistically analyze the commonly described association between cervical and thoracic somatic dysfunction. Future studies should consider a prospective design using both symptomatic and asymptomatic participants and investigate how osteopathic manipulative treatment directed at upper thoracic somatic dysfunction could concomitantly affect cervical somatic dysfunction.

Conclusion

The findings of the present study revealed statistically significant segmental associations between the cervical and thoracic spinal regions, specifically between the OA and the AA, C2, and T4 vertebral segments. The results also suggested that the number of dysfunctional segments found in the upper thoracic and midthoracic spinal regions

is directly proportional to the number of dysfunctional segments found in the upper cervical spinal region.

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Author Contributions

Dr Kappler provided substantial contributions to conception; Drs Nelson and Brindise provided substantial contributions to design, acquisition of data, or analysis and interpretation of data; Dr Brindise drafted the article or revised it critically for important intellectual content; and Drs Kappler, Nelson, and Brindise gave final approval of the version of the article to be published.

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