Frequency of Counterstrain Tender Points in Osteopathic Medical Students

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Context: Counterstrain is 1 osteopathic manipulative treatment technique taught to osteopathic medical students, but teaching all 300 counterstrain tender points is not feasible at most colleges of osteopathic medicine (COMs) because of time limitations.

Objective: To identify high-yield tender points in osteopathic medical students for teaching and to assess for correlations between tender points and demographic information, weight, and history of pain or trauma.

Methods: First- and second-year osteopathic medical students at 5 COMs were surveyed regarding the presence and absence of tender points found on themselves by fellow students. Demographic information, weight, and history of pain and trauma data were collected. The McNemar test was used to compare the frequency of positive tender points between the right and left sides. Multiple logistic regression models were fit to the data to determine if participant characteristics were related to having 1 or more positive tender points in a tender point group. Wilcoxon signed rank tests were used to compare the percentage of positive anterior vs posterior tender points. Multiple logistic regression models were used to test for differences between COMs after accounting for differences in participant characteristics.

Results: Frequency of 78 tender point groups was obtained. Forty tender point groups (51%) were positive for the presence of 1 or more tender points by 50% or more of the participants. Positive tender points were more common on the right side for 23 groups (all $P<.001$). Female participants were more likely to have tender points for 22 groups (all $P<.001$). The 20- to 25-year-olds had more tender points for 6 groups (all $P\leqslant.03$). Tender points were more common in participants with a history of pain for 29 groups (all $P<.001$) and with a history of trauma for 4 groups (all $P\leqslant.05$). Anterior tender points were more common for cervical, thoracic, rib, and lumbar body regions ($P<.001$). Differences were found between COMs for all tender point groups ($P\leqslant.02$).

Conclusion: Nearly half of the tender point groups surveyed were reported positive by 50% or more of participants, and high-yield tender points were found in each body region. Ultimately, these results may guide counterstrain curricula for COMs.

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Counterstrain is a system of osteopathic diagnosis and treatment developed in the 1950s by Lawrence H. Jones, DO.[1] Using this system, the physician assesses for and identifies tender points in musculoskeletal structures. The physician then treats the tender points by asking the patient to remain passive while the physician positions the patient's body in such a way that relief or substantial reduction of the tenderness is obtained. This position is maintained for 90 seconds.[1(pp749-762)] Many theories exist as to why tender points resolve after holding the body in a position of ease, but the most common theory is that the positioning reduces the tension on the affected tissue and decreases the nociceptive input into the spinal cord, thereby decreasing the abnormal neural reflex arc and its effect on the associated tissues.[1(pp750-751),2(ppxv-xvii),3(pp8-15),4,5] Clinically, counterstain has been used in the management of a variety of medical conditions, including myofascial pain syndrome,[6] complex regional pain syndrome,[7] arthritis,[8] facial trigger points,[9] repetitive strain injuries to the shoulder,[10] iliotibial band syndrome,[11] plantar fasciitis,[12] and even pancreatitis.[13] In a 1998 survey of osteopathic physicians,[14] nearly 85% of the respondents who used manipulation regularly used counterstrain and, overall, it was the fourth most commonly used manipulative technique. In a 2009 survey of osteopathic physicians,[15] counterstrain was reported to be used for the management of spinal dysfunction always or frequently by nearly 50% of respondents.

Counterstrain is taught as part of the osteopathic manipulative medicine (OMM) curriculum at all colleges of osteopathic medicine (COMs) in the United States (OMM chairpersons from all US COMs, personal communication, April 2011). But counterstrain, which encompasses more than 300 separate tender points, is one of many osteopathic manipulative treatment (OMT) techniques that students must learn to prepare for licensing examinations and clinical practice.[16] The Educational Council on Osteopathic Principles, a subsidiary council of the American Association of Colleges of Osteopathic Medicine that is composed of OMM department chairs or their designees, has made recommendations about what should be taught as part of the core OMM curriculum at COMs in the United States. Because of the limited number of hours each COM can dedicate to teaching counterstrain, OMM laboratory curriculums cannot include diagnosis of and treatment positions for all tender points. To maximize the impact of counterstrain instruction, we sought to identify high-yield tender points for each body region to be included in the recommended counterstrain curriculum. In our experience, high-yield tender points are easy to palpate and occur at a high frequency in the osteopathic medical student population. Positive tender points give students the experience of palpating tissue texture abnormalities on their otherwise asymptomatic colleagues. Further, applying OMT to real physical findings gives students a better chance of appreciating the tissue texture changes that occur with successful counterstrain treatment. By including tender points in the OMM laboratory curriculum that are common in the osteopathic medical school population and that have demonstrated clinical relevance, students are more likely to have positive, hands-on learning experiences with the diagnosis and treatment of counterstrain tender points.

In addition to identifying high-yield tender points for teaching, this study also assessed the relationship between participant demographics, weight, history of pain, history of trauma, and the frequency of tender points in each body region.

Methods

The current study took place from January 2010 to February 2012 at 5 COMs. The participating COMs included the A.T. Still University-Kirksville College of Osteopathic Medicine in Missouri; the A.T. Still University-School of Osteopathic Medicine in Arizona (Mesa); the Touro University California, College of Osteopathic Medicine in Vallejo; the Touro University Nevada College of Osteopathic Medicine in Henderson; and the University of New England College of Osteopathic Medicine in Biddeford, Maine. In preparation for the study, each participating COM made a list of the individual counterstain tender points taught as part of its OMM laboratory curriculum. The participating COMs taught counterstrain at different times of the year, in a different order, and with different groups of tender points for each body region (head, cervical, thoracic, ribs, lumbar, pelvis/sacrum, abdomen, upper extremity, and lower extremity). Separate scannable surveys were created for each COM for each group of tender points taught during a single laboratory session. The OMM laboratory sessions varied in length from 50 minutes to 4 hours, depending on the COM. Only tender points taught at the participating COMs as part of their established OMM laboratory curriculums were surveyed for the current study. As a result, each COM surveyed only a portion of the tender points included in the current study. Tender points that were taught in lecture or required reading formats but that were not taught in OMM laboratory sessions were not included in the current study. The survey forms included the tender points taught during that laboratory session along with participant characteristics, such as sex, age, height (in), weight (lb), race and ethnicity, history of pain in the region being evaluated, and history of significant trauma in the region. The COMs used different reference texts[2-4,17-19] when teaching counterstrain diagnosis and treatment, and in some cases those texts used different names to refer to the same tender point location. When different names were used to indicate the same point, such as *extension ankle tender point*[1(p761),17(pp92,96,98),19(pp73,78)] and *gastrocnemius tender point*,[2(p149),3(p127)] both names were included on all forms that surveyed those points.

After approval from the local institutional review board at each COM, first- and second-year osteopathic medical students at the 5 participating COMs were surveyed regarding the presence or absence of positive tender points found on themselves by fellow students during the counterstrain laboratory sessions. Participation in the study was voluntary. Students who were not present for the counterstrain laboratory sessions were excluded from the study. The survey forms were handed out at the beginning of the laboratory session and turned in to the site investigator at the end of the laboratory session. The site investigator at each COM was responsible for providing survey instructions and overseeing data collection. During the OMM laboratory sessions, participants typically worked in pairs, alternating between practicing diagnosis and treatment and being practiced on. Participants either self-selected their partner or were assigned a partner, depending on the COM. Each participant recorded his or her own participant characteristics on the survey forms. Using palpation, the participant's partner determined the presence or absence of each surveyed tender point on the participant. The tender point data were recorded on the survey by either the participant or the participant's partner. The information obtained about the tender points included the relative location of the tender point, such as right, left, midline, or none, and the severity of the tenderness at the point, if present. Severity was recorded as mild if the participant reported mild tenderness and there was no flinch or withdrawal response. Severity was recorded as significant if the participant reported marked pain or tenderness or if there was a flinch or withdrawal response. In cases with multiple tender point locations for a single named tender point, such as posterior T2, which included midline, right spinous process, left spinous process, right transverse process, and left transverse process locations, all tender point locations were recorded, but only the severity of the most painful tender point of the group was noted.

Participants were instructed on appropriate palpatory technique for assessing tender points by laboratory instructors and table trainers during the laboratory sessions. Although the instructions for study participation were standardized, no attempt was made to standardize the laboratory instruction; each COM used its own handouts and other teaching materials. Each COM allowed time within the laboratory session to complete the surveys. Although student participation in the study was voluntary, all COMs required participation in the laboratory sessions.

Statistical Analysis

Completed surveys were returned to the A.T. Still Research Institute for data analysis. Participant characteristics were summarized as frequencies and percentages (weight was summarized as mean and standard deviation) for each survey. The mean and range of the frequencies and percentages (mean and standard deviation for weight) were calculated for each COM and for all surveys combined.

Individual tender point locations were grouped together for data analysis on the basis of body region and the anatomical locations of the tender points (eg, the anterior C2-C6 tender point group consisted of the 10 tender points located at the anterior aspect of the transverse processes of the C2-C6 vertebrae). For each tender point group, the frequency and percentage of students with 1 or more positive tender points were calculated. The frequency and percentage of students with 1 or more tender points with significant severity and the percentage with only mild severity within the tender point group were also calculated.

The McNemar test was used to compare the frequency of positive tender points between the right and left sides of the body. Multiple logistic regression models were fit to the data to determine the participant characteristics that were related to having 1 or more positive tender points in a tender point group. Using data from participants surveyed for anterior and posterior tender points within the same body region on the same day, Wilcoxon signed rank tests were used to compare the percentage that were positive between anterior and posterior tender points. Multiple logistic regression models were also used to test for differences between COMs after accounting for potential differences in participant characteristics. Statistical analyses were conducted using SAS software (version 9.3; SAS Institute Inc). $P \leqslant .05$ was considered statistically significant.

Results

Among all COMs, 49 surveys were distributed over 25 months, and a mean of 111 students (range, 25-175) participated per survey (*Table 1*). Participant characteristics are summarized in *Table 2*. Survey forms were evenly distributed between male (mean frequency [mean %], 55 [51]) and female (mean frequency [mean %], 50 [49]) participants. The majority of participants reported being aged 20 to 25 years (mean frequency [mean %], 65 [57]), white (mean frequency [mean %], 81 [72]), and non-Hispanic (mean frequency [mean %], 71 [95]). Approximately one-third (mean frequency [mean %], 32 [32]) of the participants reported no history of pain, and most (mean frequency [mean %], 87 [84]) reported no history of trauma in the body region being assessed.

eTable 1 lists the frequency of occurrence, severity, and sidedness for the 78 tender point groups assessed in the head, cervical, thoracic, rib, lumbar, pelvis/sacrum, and upper and lower extremity body regions. The tender point groups with the lowest number of reported positive tender points were posterior C8 medial (right and left) (58 of 558 participants [10%] with 1 or more tender points in the group) and posterior C8 medial (midline) (41 of 423 participants [10%]). The tender point group with the highest number of reported positive tender points was anterior R1 through R6 (702 of 758 participants [93%]). Forty tender point groups (51%) were reported positive for the presence of 1 or more tender points by 50% or more of the participants, with the 4 most common being the navicular (237 of 298 participants [80%]), anterior C2-C6 (629 of 768 participants [82%]), posterior R1-R6 (648 of 738 participants [88%]), and anterior R1-R6 (702 of 758 participants [93%]) tender point groups.

For 11 of the 78 tender point groups (14%), participants reported more significant severity tender points

Table 1.
Surveys of Counterstrain Tender Point Frequency in Osteopathic Medical Students, by College of Osteopathic Medicine (COM)

Outcome Measure	All COMs	ATSU-KCOM	ATSU-SOMA	TUCOM	TUNCOM	UNECOM
Surveys, No.						
Total	49	16	4	8	9	12
OMS I	34	6	4	7	7	10
OMS II	15	10	0	1	2	2
No. of Participants per Survey, Mean (range)						
Total	111 (25-175)	160 (148-175)	91 (51-105)	107 (41-124)	60 (25-76)	93 (61-113)
OMS I	100 (25-175)	174 (148-175)	91 (51-105)	105 (41-124)	57 (25-68)	93 (61-113)
OMS II	139 (65-163)	157 (153-163)	0	118	71 (65-76)	97 (96-98)

Abbreviations: ATSU-KCOM, A.T. Still University-Kirksville College of Osteopathic Medicine; ATSU-SOMA, A.T. Still University-School of Osteopathic Medicine in Arizona; OMS, osteopathic medical student; TUCOM, Touro University-California College of Osteopathic Medicine; TUNCOM, Touro University Nevada College of Osteopathic Medicine; UNECOM, University of New England College of Osteopathic Medicine.

than mild severity tender points, including the anterior T7-T11 midline; posterior T1-T12 midline spinous process, inferolateral spinous process, and transverse process; anterior R1-R6; posterior R1-R6; anterior L5; upper pole L5 (UPL5); lower pole L5 (LPL5); posterior L3-L4 lateral (gluteus medius); and low ilium tender point groups.

Positive tender points were more common on the right side of the body for 23 groups ($P \leq .05$), including the masseter ($P = .02$), anterior C1 mandible ($P < .001$), anterior C2 through C8 ($P \leq .03$), posterior C1 lateral occiput ($P = .01$), posterior T1-T12 inferolateral spinous process ($P < .001$), posterior R1 through R6 ($P < .001$), posterior L1-L5 inferolateral spinous process ($P = .046$), UPL5 ($P < .001$), LPL5 ($P = .01$), and high ilium (high ilium sacroiliac) ($P < .001$). In the upper extremity, positive tender points were more common on the right supraspinatus ($P < .001$), infraspinatus ($P = .008$), subscapularis ($P = .02$), levator scapulae ($P = .004$), biceps—long head ($P = .009$), latissimus dorsi ($P < .001$), palmar wrist (flexor carpi radialis/ulnaris and flexor digitorum superficialis and profundus) ($P < .001$), dorsal wrist ($P = .05$), first carpometacarpal (abductor pollicis brevis) ($P = .03$), extensor digitorum ($P = .03$), and flexor pollicis brevis ($P = .001$). No lower extremity tender points were more positive on the right side of the body. Positive tender points were more common on the left side for anterior L2 ($P = .01$), gluteus minimus ($P = .005$), popliteus ($P = .046$), and extension ankle (gastrocnemius and soleus) ($P = .049$) tender point groups. Three hundred eighty-six of 613 participants (63%) had 1 or more positive tender points in the iliacus (iliopsoas/psoas) tender point group, with no statistically significant sidedness ($P = .21$). Three surveys assessed for iliacus separately from psoas; when they were analyzed for right-left disparities, no significant difference ($P = .93$) was found between the right (94 of 288 [33%]) and left (95 of 288 [33%]) sides.

eTable 2 presents analysis of the relationship between participant characteristics (ie, sex, age, weight, race, history of pain, and history of trauma) and 86 tender point groups. This table includes the 78 groups presented in

Table 2.
Characteristics of Students Surveyed on Counterstrain Tender Point Frequency, by College of Osteopathic Medicine (COM)

Characteristic, Mean No. (Mean %)[a]	All COMs	ATSU-KCOM	ATSU-SOMA	TUCOM	TUNCOM	UNECOM
Sex						
Male	55 (51)	90 (59)	42 (53)	51 (50)	31 (54)	35 (38)
Female	50 (49)	64 (41)	38 (47)	51 (50)	25 (46)	56 (62)
Age, y						
20-25	65 (57)	99 (63)	45 (49)	56 (52)	29 (49)	57 (62)
26-30	36 (33)	52 (33)	32 (36)	36 (35)	22 (37)	26 (28)
31-40	8 (9)	6 (4)	11 (13)	12 (11)	8 (14)	8 (8)
41-50	1 (1)	<1 (<1)	2 (2)	2 (1)	1 (1)	2 (2)
Weight, lb, mean (SD)						
Male	179 (32)	181 (29)	178 (35)	174 (41)	178 (34)	176 (28)
Female	137 (25)	140 (27)	135 (21)	134 (27)	133 (27)	136 (20)
Race						
White	81 (72)	132 (85)	48 (57)	53 (51)	32 (54)	80 (88)
Asian	17 (19)	15 (10)	25 (29)	35 (34)	19 (34)	5 (6)
Black/African American	1 (1)	2 (1)	0	<1 (<1)	1 (2)	1 (1)
American Indian/ Alaskan Native	<1 (<1)	1 (<1)	0	<1 (<1)	<1 (<1)	0
Native Hawaiian/ Other Pacific Islander	<1 (<1)	<1 (<1)	1 (2)	1 (1)	<1 (1)	0
Other race	3 (3)	1 (1)	5 (5)	6 (6)	3 (5)	2 (3)
Multiple races	4 (4)	4 (3)	7 (7)	9 (9)	3 (5)	2 (2)
Ethnicity						
Hispanic/Latino	3 (5)	4 (3)	8 (15)	4 (6)	2 (8)	2 (3)
Non-Hispanic/Latino	71 (95)	113 (97)	47 (85)	66 (94)	29 (92)	60 (97)
History of Pain in Body Region						
Current new symptoms	4 (4)	6 (4)	4 (4)	4 (4)	3 (5)	3 (3)
Recurrent intermittent symptoms	20 (20)	31 (20)	12 (15)	23 (26)	12 (22)	13 (14)
Chronic long-standing symptoms	8 (8)	11 (7)	8 (11)	8 (9)	4 (8)	7 (8)
No history of pain (in past 6 weeks)	32 (32)	48 (31)	24 (30)	35 (39)	19 (35)	22 (26)
History of Trauma in Body Region						
"Significant" sprain/ strain/fracture	15 (14)	24 (16)	5 (8)	15 (16)	7 (12)	13 (15)
No history of trauma	87 (84)	128 (84)	56 (67)	84 (84)	49 (88)	74 (85)

[a] Data presented as mean No. (mean %) unless otherwise indicated. Data were summarized for each survey, and mean and range were calculated for each COM and for all surveys combined.

Abbreviations: ATSU-KCOM, A.T. Still University-Kirksville College of Osteopathic Medicine; ATSU-SOMA, A.T. Still University-School of Osteopathic Medicine in Arizona; OMS, osteopathic medical student; SD, standard deviation; TUCOM, Touro University California, College of Osteopathic Medicine; TUNCOM, Touro University Nevada College of Osteopathic Medicine; UNECOM, University of New England College of Osteopathic Medicine.

eTable 1, as well as 8 subgroups analyzed separately from a larger group, such as the anterior R2 lateral and medial tender point locations. For this set of analyses, only data from surveys in which all the participant characteristics were completed were included, thus accounting for the different sample sizes between *eTable 1* and *eTable 2* for the same tender point groups. All participant characteristics were related to having positive tender points in at least 1 tender point group (*eTable 2*).

Female participants were more likely to have positive tender points than male participants in 22 tender point groups ($P \leq .04$), including posterior C1 inion (midline) ($P = .005$), posterior C1 lateral occiput ($P = .02$), posterior C1-C8 ($P \leq .03$), anterior T1-T6 midline ($P < .001$), anterior R1-R10 ($P \leq .005$), posterior L1-L5 inferolateral spinous processes ($P = .04$), UPL5 ($P < .001$), LPL5 ($P = .01$), and gluteus maximus (midpole sacroiliac/flare in sacroiliac) ($P = .003$) tender point groups (*eTable 2*). In the extremities, female participants were more likely to have positive tender points than male participants in the infraspinatus ($P < .001$), subscapularis ($P = .006$), extensor digitorum ($P = .04$), lateral and posterior lateral trochanter ($P = .01$), medial and lateral meniscus ($P < .001$), and extension ankle (gastrocnemius and soleus) ($P = .02$) tender point groups. Male participants were more likely to have positive flexor pollicis brevis tender points ($P = .048$). Female participants had significantly more severe tender points than male participants for the rib ($P = .01$) and thoracic ($P = .005$) regions.

Those in the youngest age group (ie, 20- to 25-year-olds) were more likely to have positive tender points than 1 or both of the other age groups (ie, 26- to 30-year-olds and 31- to 50-year-olds) for the posterior R7-R10 ($P = .01$), anterior L1 ($P = .002$) and L3 ($P = .02$), posterior L3-L4 lateral (gluteus medius) ($P = .049$), posterior lateral trochanter ($P = .03$), and extension ankle (gastrocnemius and soleus) ($P = .03$) tender point groups and less likely to have positive tender points for the palmar wrist (flexor digitorum superficialis and profundus) tender point group ($P = .03$) (*eTable 2*).

Increased weight was related to increased probability of having a positive tender point for the anterior C7 ($P = .01$) and C8 ($P < .001$), anterior and posterior R7-R10 ($P = .001$ and $P = .003$, respectively), infraspinatus medial ($P = .03$), subscapularis ($P = .008$), hamstring (medial and lateral) ($P = .02$), and medial meniscus ($P = .05$) tender point groups and to decreased probability for the posterior R1-R6 ($P = .03$) and posterior L3-L4 lateral (gluteus medius) ($P = .03$) tender point groups (*eTable 2*).

For the 4 tender point groups to which race was related (ie, posterior C1 inion [right/left], anterior T1-T6 midline, anterior L3, and UPL5), white participants were less likely to have positive tender points than Asian participants, participants of other races, or both (all $P \leq .05$) (*eTable 2*).

Participants with current new pain symptoms in the body region were more likely to have positive posterior C1 lateral occiput ($P = .02$), posterior C8 lateral ($P = .01$), and anterior T7-T11 lateral ($P = .049$) tender points and less likely to have positive posterior T1-T12 transverse process tender points ($P = .007$) (*eTable 2*). Those with recurrent intermittent pain symptoms were more likely to have positive anterior C7 ($P = .003$); posterior C1 and C2 lateral occiput (both $P = .02$); anterior T7-T11 lateral ($P < .001$); posterior T1-T12 midline spinous process ($P = .04$); anterior L1, L3, L4, and L5 ($P = .001$, $P = .006$, $P = .005$, and $P < .001$, respectively); UPL5 and LPL5 (both $P < .001$); low ilium ($P = .01$); high ilium (high ilium sacroiliac) ($P < .001$); biceps—long head ($P = .02$); lateral trochanter ($P = .03$); posterior lateral trochanter ($P = .03$); lateral ankle (peroneus longus and brevis) ($P = .001$); and navicular ($P = .04$) tender points and less likely to have positive posterior R1-R6 tender points ($P = .03$). Chronic long-standing pain symptoms were related to positive posterior C1 lateral occiput ($P < .001$); anterior L1, L4, and L5 ($P = .01$, $P = .01$, and $P = .02$, respectively); posterior L3-L4 lateral (gluteus medius) ($P = .01$); UPL5 and LPL5 ($P = .02$ and $P = .04$, respectively); inguinal (pectineus) ($P = .04$); high ilium (high ilium sacroiliac) (P=.05); gluteus maximus (midpole sacroiliac/flare in sacroiliac) (P=.02); coccygeus (high ilium flare out) (P=.02); infraspinatus (P=.02); infraspinatus lateral (P=.049); lateral meniscus (P=.05); flexion calcaneus (quadratus plantae) (P=.02); medial calcaneus (abductor hallucis) (P=.006); extension ankle (gastrocnemius and soleus) (P=.02); and navicular (P=.04) tender points.

Participants with history of trauma in the body region were more likely to have positive tender points for the anterior L3 (P=.04), posterior L1-L5 midline spinous process and transverse process (P=.05 and P=.02, respectively), and palmar wrist (flexor carpi radialis/ulnaris and flexor digitorum superficialis and profundus) (P=.05) tender point groups and less likely to have positive tender points for the posterior C1-C7 (midline) (P=.04) and posterior L3-L4 lateral (gluteus medius) (P=.04) tender point groups (*eTable 2*).

Positive anterior tender points were more common than positive posterior tender points for cervical, thoracic, rib, and lumbar body regions (P<.001).

Differences were found between the COMs for all tender point groups (P≤.02) except the posterior C1 inion (midline) (P=.65), posterior C8 medial (midline) (P=.17), high ilium (high ilium sacroiliac) (P=.12), coccygeus (high ilium flare out) (P=.61), supraspinatus (P=.22), infraspinatus medial (P=.37), levator scapulae (P=.24), biceps—long head (P=.14) and biceps—short head (coracobrachialis) (P=.43), posterior lateral trochanter (P=.65), medial (P=.09) and lateral (P=.90) meniscus, patellar (P=.35), flexion calcaneus (quadratus plantae) (P=.15), and medial ankle (P=.07) tender points.

Comment

In the current study, tender points were found to be more common on the right side of the body for 27 of 78 tender point groups. In a similar population of osteopathic medical students, Liu and Palmer[20] found that the iliacus tender points were more common on the right side. The current study, however, did not find laterality for the iliacus, iliopsoas, and psoas tender point group. Fernández-de-las-Peñas et al[21] found that right-sided tender and trigger points in the head and neck regions were more common in asymptomatic individuals and in individuals with mechanical neck pain, but Chung et al[22] demonstrated no side-to-side differences in the same body regions in asymptomatic individuals. Studies have also demonstrated a predominance of right-sided tender points in individuals with chronic tension headaches[23,24] and fibromyalgia.[25] These findings may be related to the predominance of right-handedness in the population, which is associated with a greater use of right-sided muscles. Several studies[26,27] have demonstrated that handedness affects pain perception. The pain pressure threshold (PPT), which is the minimum amount of pressure needed to induce the subjective sensation of pain,[28] is typically lower on the nondominant side (ie, the left side) in right-handed individuals.[29-32] Handedness data of the participants were not collected in the current study, but given that approximately 90% of the population is right handed,[33] a future study could investigate if the predominance of right-sided tender points is related to handedness.

Seven of 86 tender point groups in the current study showed statistically significant variability with age. For 6 of those 7 tender point groups, the 20- to 25-year-olds had more tender points than 1 or more of the older age groups. Several studies have demonstrated that younger adults have lower PPTs than older adults.[29,30,34] This finding may be because of age-related changes in the sensory neurons.[35-37] The current study had a maximum of 13 participants aged 40 to 50 years for any given tender point group. The age-related variability may have been greater if more participants aged 40 to 70 years had been included.

Eighty-six tender point groups were assessed for sex correlations. Of these, 22 were statistically more common in female participants, who had a higher severity of tender points than male participants for the thoracic and rib regions. This finding is consistent with numerous studies[28,29,32,34,38-42] that have demonstrated that women typically have lower PPTs than men. Isselee et al[43] also demonstrated that PPTs can vary with hormonal cycles in menstruating women. Widespread myofascial tenderness, which occurs in such disorders as fibromyalgia, is more common in the female population.[44-48] The higher level of sensitivity in women may be because of an increased likelihood of central sensitization caused by higher levels of temporal summation and increased central nociceptive processing.[38,48-50] Stisi et al[50] concluded in their literature review that men have more effective "diffuse noxious inhibitory control." In the current study, only the flexor pollicis brevis tender points were more common in male participants than in female participants. This location was only assessed in 46 students, however, with a 22% prevalence. Evaluation of a larger group of students may result in different findings.

The current study found that recurrent and chronic low back pain was associated with many tender points in the anterior and posterior lumbar regions. Two studies have demonstrated that lumbar somatic dysfunction is more common in individuals with low back pain.[51-53] Farasyn and Meeusen[42] found that, compared with asymptomatic individuals, people with subacute low back pain have statistically significant lower PPTs in the musculature of the thoracic, lumbar, and pelvic regions. Other studies have also noted that PPTs are lower in individuals with low back pain.[54,55] The lower PPT in patients with low back pain is likely a result of the sensitization of nociceptors; sensitized neurons have a lower firing threshold and thus an increased sensitivity to mechanical stimuli.[54,56-58] This sensitization is also known as facilitation.[59-61]

In the current study, anterior L1 and L3 through L5 were all correlated with recurrent or chronic lumbar pain. This finding supports Jones' hypothesis that these tender points, which are found on the anterior pelvic brim, are functionally associated with the lumbar region.[3(pp7-22,101,102)] Unfortunately, this study could not specifically assess the relationship between the anterior and posterior lumbar tender points because the 2 sets of points were frequently taught on separate occasions.

The current study found that anterior tender points occurred at a higher frequency than posterior tender points in all axial regions (cervical, thoracic, rib, and lumbar). No mention of this observation could be found within the literature, but it is likely because the thicker skin on the back has a lower level of tactile discrimination[62,63] and a lower density of intraepidermal sensory nerve fibers[64] than the skin on the anterior trunk.

Several limitations should be considered when interpreting the data from the current study. Statistically significant differences in the frequency of the tender points were found at the different COMs. These differences may be a result of a variety of factors, including differences in the amount of pressure used to assess tender points, teaching style and experience of the presenter, laboratory set up, and the ergonomics of the seating in the main lecture classroom resulting in different patterns of tender points. A study on these differences is in process.

Although comparison of the palpatory abilities of first- and second-year osteopathic medical students would yield valuable information regarding the impact of additional training on the ability of students to identify tender points, the current study was not designed to assess this question. None of the COMs had OMM laboratory sessions in their curriculums that included both first- and second-year students evaluating the same tender points, and 1 participating COM conducted OMM laboratory sessions only during the first year of medical school. Therefore, future studies should longitudinally assess the ability of students to identify the same tender points over the course of their training.

The current study also had several problems with data collection that may have impacted data analysis. Although participants were instructed to choose up to 4 races (if multiracial) and to indicate if they were Hispanic or non-Hispanic, some students indicated only that they were Hispanic, without mention of racial origin. As a result, race and ethnicity were analyzed separately. Next, participants were instructed to indicate their height in inches. However, many participants filled in the scan form using feet and inches. For example, if a participant reported their height as 5 ft 5 in, the scan form would read their height was 55 in, or 4 ft 8 in. Thus, an unlikely number of participants indicated that they were less than 5 ft tall. Of the 5432 participants who completed surveys, 876 (16%) reported a height less than 5 ft tall, a result that is atypical for the adult population in the United States.[65] Further, 3465 participants (64%) reported a height of at least 5 ft but less than 6 ft, and 984 (18%) reported a height of 6 ft or taller. For 107 surveys (2%), participants did not give their height. Because of the high frequency of this recording error, the relationship of body mass index and the location of tender points could not be analyzed. Future studies should collect height data using feet and inches to prevent this recording error. Lastly, participants were instructed to indicate "none" on the data collection forms if no tender points were found at a given location. But many participants appear to have left the survey blank at locations when no tender points were found, so we could not distinguish whether tender points were not found or tender points were not assessed. When tender point locations were left blank, we assumed that the tender point locations had not been assessed and did not include them in data analysis. This assumption may have resulted in inflated estimates of the frequency of positive tender points.

As stated previously, the participating COMs used different counterstrain references, and different references describe the locations of the named tender points slightly differently. For example, Rennie and Glover[3(p111)] describe the location of the UPL5 tender points as the spinous process of L5 or between the L5 spinous process and the posterior superior iliac spine. This location is consistent with that mentioned in 1986 by Schwartz, who described the UPL5 as "located medially between the spinous process of L5 and the spinous process of the first sacral segment."[66] In his 1981 publication, Jones[17(pp60,72,73)] described the UPL5 tender point on the superior medial surface of the posterior superior iliac spine, but in his 1995 publication[67] he did not use the term UPL5 at all and described the "superio-medial edge" of the posterior superior iliac spine as "the place to look for L5 dysfunction." The frequency of the tender points noted in the current study included all locations tested for each point surveyed.

Another limitation of the current study is that the examiners of the tender points were osteopathic medical students who had not been exposed to the location of the tender points prior to that laboratory session. We acknowledge that this limitation may be substantial as it relates to the overall accuracy of palpation as well as the applicability to outside populations. Although a high frequency of occurrence of a particular group of tender points, such as the anterior R1-R6 tender points,[3(pp52,54),17(pp56,64),18(p759),19(pp28-29)] likely indicates a high prevalence within the osteopathic medical school population, the reverse cannot be inferred. For example, the frequency of the iliacus, iliopsoas, and psoas tender point group[2(pp73,102),3(p103),17(pp56,64),18(p761),19(p36)] was 63% in the current study, whereas a recent study[20] found the frequency to be 94% in a similar population of osteopathic medical students when assessed by a trained examiner. This frequency may be reflective of the difficulty experienced by the novice learner in locating the tender point rather than the actual prevalence within the study population. This limitation was part of the study design. For tender points to be high yield for the OMM laboratory curriculum, they must be both easy to locate and occur at high prevalence. Despite this limitation, the current study found tender point associations similar to those found by studies with experienced examiners, particularly associations with sex,[28,29,32,34,38-43] age,[29,30,34] right-sided predominance,[20,21,23-25] and low back pain.[51-53]

As a subjective observation, the site investigators noted that when participants were filling out the survey forms regarding the tender points, they were much more thorough in checking each named tender point location. The increased attentiveness of the participants was an unintended consequence of the current study, but it may indicate that filling out the forms can be a useful exercise to facilitate learning of the material.

We have observed that students learn best when they have positive, successful learning experiences. In OMM, that would mean learning techniques that are easy to comprehend and demonstrate, while allowing the opportunity to palpate physical changes before and after treatment. More than 20 different types of OMT techniques are described in the *Glossary of Osteopathic Terminology*, each with many variations for different somatic dysfunctions.[68] Techniques taught as part of the OMM curriculum at the different COMs are based on national licensing board examinations and the experience of the faculty. When learning OMM during the first- and second-year laboratory curriculum, osteopathic medical students practice on fellow students. These students are typically asymptomatic and, therefore, are not representative of particular clinical cases. Because counterstrain pedagogy requires the presence of substantial tenderness to practice the principles of the technique, the current study was designed to identify high-yield tender points in an otherwise healthy population to maximize osteopathic medical students' early experiences in counterstrain technique. The concepts used in our study can be applied to other types of OMT to identify additional high-yield somatic dysfunctions in osteopathic medical students. By surveying students about other types of somatic dysfunction, common diagnoses may be identified that could be used, along with diagnoses that have demonstrated clinical relevance, as part of the core of the OMM laboratory curriculum. With regard to different types of techniques, students and educators could be surveyed to discern which techniques are more easily learned at a beginner's level. Then, recommendations could be made for core techniques to teach in the first- and second-year osteopathic medical school curriculums and for techniques best taught in a 1:1 setting, such as in clinical rotations or advanced OMM courses.

Conclusion

Nearly half of the 78 tender point groups surveyed in the current study were reported positive by 50% or more of the students, and each body region demonstrated high-yield tender points for use in the OMM laboratory curriculum. In the spring of 2012, the Educational Council on Osteopathic Principles met to review and revise recommendations regarding which tender points should be covered in a core OMM curriculum. The results of the current study were reviewed at that meeting, and high-yield tender points from each region of the body, along with clinically relevant tender points identified through expert opinion, were included in the revision of the counterstrain core curriculum. This revised curriculum is expected to be published in the future. In addition, this line of research could be further expanded by using large-scale clinical research approaches, such as practice-based research networks, to identify the most clinically relevant tender points. Ultimately, the results of the current and other studies will help guide the recommended counterstrain core curriculum for COMs nationwide.

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eTable 1.
Tender Point Frequencies and Related Variables in Surveyed Osteopathic Medical Students

Tender Point Group By Body Area	Students				Right vs Left *P* Value[c]
	Surveyed, No.	Positive Tender Points, No. (%)[b]	Severity, No. (%)[a]		
			Mild	Significant	
Head					
Medial pterygoid	91[d]	52 (57)	32 (37)	15 (17)	.30
Temporalis	92[d]	35 (38)	26 (29)	6 (7)	.06
Masseter	92[d]	45 (49)	26 (30)	14 (16)	**.02 (right>left)**
Cervical					
Anterior C1 mandible	753	548 (73)	288 (40)	225 (31)	**<.001 (right>left)**
Anterior C1 transverse process	482	294 (61)	169 (37)	102 (22)	.84
Anterior C2-C6	768	629 (82)	353 (48)	247 (33)	**<.001 (right>left)**
Anterior C7	726	292 (40)	171 (25)	90 (13)	**<.001 (right>left)**
Anterior C8	722	292 (40)	173 (25)	82 (12)	**.03 (right>left)**
Posterior C1 inion (right/left)	491	96 (20)	55 (12)	24 (5)	>.99
Posterior C1 inion (midline)	373	54 (14)	40 (11)	9 (2)	NA
Posterior C1 lateral occiput	686	301 (44)	198 (31)	63 (10)	**.01 (right>left)**
Posterior C2 lateral occiput	668	236 (35)	154 (24)	45 (7)	.50
Posterior C1-C7 (right/left)	736	438 (60)	218 (32)	166 (24)	.75
Posterior C1-C7 (midline)	596	275 (46)	153 (27)	101 (18)	NA
Posterior C8 medial (right/left)	558	58 (10)	26 (5)	15 (3)	.42
Posterior C8 medial (midline)	423	41 (10)	27 (6)	7 (2)	NA
Posterior C8 lateral	416	80 (19)	53 (13)	17 (4)	.17
Thoracic					
Anterior T1-T6 midline	796	607 (76)	318 (41)	268 (35)	NA
Anterior T7-T11 midline	393	90 (23)	39 (10)	46 (12)	NA
Anterior T7-T11 lateral	773	454 (59)	243 (32)	192 (25)	.23
Anterior T12 iliac crest	739	356 (48)	200 (28)	139 (19)	.11
Posterior T1-T12 midline spinous process	907	441 (49)	48 (5)	383 (43)	NA
Posterior T1-T12 inferolateral spinous process	907	530 (58)	82 (9)	436 (49)	**<.001 (right>left)**
Posterior T1-T12 transverse process	849	523 (62)	56 (7)	459 (55)	.06
Ribs					
Anterior R1-R6	758	702 (93)	238 (32)	441 (60)	.34
Anterior R7-R10	317[d]	183 (58)	105 (34)	73 (23)	.46
Posterior R1-R6	738	648 (88)	280 (40)	326 (47)	**<.001 (right>left)**
Posterior R7-R10	311[d]	143 (46)	93 (30)	47 (15)	.10

(continued)

[a] Most severe tender point within group. Some surveys did not indicate the severity of the tender points.
[b] Number of students with 1 or more positive tender points per tender point group.
[c] McNemar test. Statistically significant findings appear in **boldface**.
[d] Only surveyed at 1 school.

Abbreviations: HIFO, high ilium flare out; HISI, high ilium sacroiliac; MPSI/FISI, midpole sacroiliac/flare in sacroiliac; NA, not applicable.

eTable 1 *(continued)*.
Tender Point Frequencies and Related Variables in Surveyed Osteopathic Medical Students

Tender Point Group By Body Area	Students				Right vs Left *P* Value[c]
	Surveyed, No.	Positive Tender Points, No. (%)[b]	Severity, No. (%)[a]		
			Mild	Significant	
Lumbar					
Anterior L1	782	363 (46)	215 (28)	132 (17)	.11
Anterior L2	794	473 (60)	252 (32)	208 (27)	**.01 (left>right)**
Anterior L3	770	301 (39)	164 (22)	118 (16)	.57
Anterior L4	784	328 (42)	176 (23)	135 (18)	.37
Anterior L5	800	538 (67)	238 (31)	275 (35)	.30
Posterior L1-L5 midline spinous process	829	247 (30)	129 (16)	98 (12)	NA
Posterior L1-L5 inferolateral spinous process	829	311 (38)	167 (21)	116 (14)	**.046 (right>left)**
Posterior L1-L5 transverse process	868	319 (37)	167 (20)	126 (15)	.53
Posterior L3-L4 lateral (gluteus medius)	685	427 (62)	87 (14)	290 (46)	.25
Upper pole L5	653	183 (28)	36 (6)	106 (17)	**<.001 (right>left)**
Lower pole L5	680	307 (45)	53 (8)	221 (34)	**.01 (right>left)**
Pelvis/Sacrum					
Iliacus (iliopsoas/psoas)	613	386 (63)	227 (38)	146 (24)	.21
Inguinal (pectineus)	522	366 (70)	184 (36)	165 (33)	.77
Gluteus minimus	324[d]	127 (39)	92 (29)	30 (9)	**.005 (left>right)**
Low ilium	115	67 (58)	27 (24)	36 (32)	.25
Piriformis (PIR)	544	308 (57)	193 (37)	99 (19)	.86
High ilium (HISI)	585	240 (41)	171 (30)	50 (9)	**<.001 (right>left)**
Gluteus maximus (MPSI/FISI)	503	224 (45)	160 (33)	49 (10)	.23
Coccygeus (HIFO)	518	121 (23)	91 (18)	17 (3)	.56
Upper Extremity					
Supraspinatus	483	292 (60)	205 (43)	77 (16)	**<.001 (right>left)**
Infraspinatus	482	297 (62)	248 (52)	41 (9)	**.008 (right>left)**
Subscapularis	479	315 (66)	160 (34)	141 (30)	**.02 (right>left)**
Levator scapulae	481	337 (70)	194 (42)	125 (27)	**.004 (right>left)**
Biceps—long head	484	269 (56)	188 (39)	77 (16)	**.009 (right>left)**
Biceps—short head (coracobrachialis)	481	260 (54)	174 (37)	78 (16)	.24

(continued)

[a] Most severe tender point within group. Some surveys did not indicate the severity of the tender points.
[b] Number of students with 1 or more positive tender points per tender point group.
[c] McNemar test. Statistically significant findings appear in **boldface**.
[d] Only surveyed at 1 school.

Abbreviations: HIFO, high ilium flare out; HISI, high ilium sacroiliac; MPSI/FISI, midpole sacroiliac/flare in sacroiliac; NA, not applicable.

eTable 1 *(continued)*.
Tender Point Frequencies and Related Variables in Surveyed Osteopathic Medical Students

	Students				
			Severity, No. (%)[a]		
Tender Point Group By Body Area	Surveyed, No.	Positive Tender Points, No. (%)[b]	Mild	Significant	Right vs Left *P* Value[c]
Upper Extremity *(continued)*					
Latissimus dorsi	108	65 (60)	45 (45)	13 (13)	<**.001 (right>left)**
Radial head (supinator)	479	311 (65)	188 (40)	118 (25)	.07
Triceps (lateral olecranon)	307[d]	167 (54)	109 (36)	56 (18)	.16
Pronator (medial epicondyle)	481	229 (48)	152 (32)	67 (14)	.42
Palmar wrist (flexor carpi radialis/ ulnaris and flexor digitorum superficialis and profundus)	413	141 (34)	108 (26)	30 (7)	<**.001 (right>left)**
Dorsal wrist	109[d]	26 (24)	19 (18)	4 (4)	**.05 (right>left)**
First carpometacarpal (abductor pollicis brevis)	310[d]	211 (68)	155 (51)	52 (17)	**.03 (right>left)**
Extensor digitorum	65[d]	13 (20)	8 (13)	2 (3)	**.03 (right>left)**
Flexor pollicis brevis	62[d]	17 (27)	10 (17)	4 (7)	**.001 (right>left)**
Lower Extremity					
Lateral trochanter	595	366 (62)	224 (39)	122 (21)	.39
Posterior lateral trochanter	423	288 (68)	176 (43)	101 (25)	.95
Posterior medial trochanter	112[d]	46 (41)	24 (22)	19 (17)	.33
Cruciate/hamstring/popliteus	574	446 (78)	331 (60)	92 (17)	>.99
Cruciate (anterior and posterior)	200	112 (56)	64 (33)	40 (21)	.21
Hamstring (medial and lateral)	571	408 (71)	289 (53)	95 (17)	.52
Popliteus	50[d]	20 (40)	10 (22)	6 (13)	**.046 (left>right)**
Medial meniscus	418	249 (60)	150 (37)	90 (22)	.33
Lateral meniscus	414	178 (43)	126 (31)	46 (11)	.55
Patellar	145	39 (27)	23 (17)	9 (7)	>.99
Flexion calcaneus (quadratus plantae)	559	217 (39)	150 (28)	47 (9)	.08
Medial calcaneus (abductor hallucis)	349	190 (54)	126 (37)	60 (17)	.18
Lateral ankle (peroneus longus and brevis)	560	389 (69)	266 (49)	104 (19)	.85
Extension ankle (gastrocnemius and soleus)	567	435 (77)	266 (49)	150 (27)	**.049 (left>right)**
Medial ankle	227	123 (54)	65 (32)	35 (17)	.53
Navicular	298[d]	237 (80)	121 (41)	110 (38)	.74

[a] Most severe tender point within group. Some surveys did not indicate the severity of the tender points.
[b] Number of students with 1 or more positive tender points per tender point group.
[c] McNemar test. Statistically significant findings appear in **boldface**.
[d] Only surveyed at 1 school.

Abbreviations: HIFO, high ilium flare out; HISI, high ilium sacroiliac; MPSI/FISI, midpole sacroiliac/flare in sacroiliac; NA, not applicable.

eTable 2.
Multiple Logistic Regression Model Predicting Probability of Surveyed Osteopathic Medical Students Having Positive Tender Points Based on Characteristics

Tender Point Group by Body Area	N	Positive Tender Points	*P* Values[a] Sex	Age[b]	Weight	Race[c]	Pain: Current	Pain: Intermittent	Pain: Chronic	Trauma
Head										
Medial pterygoid	65	36 (55)	.57	.75	.94	NA[d]	NA[d]	.18	.45	NA[d]
Temporalis	65	22 (34)	.84	.30	.14	NA[d]	NA[d]	.41	.55	NA[d]
Masseter	65	30 (46)	.79	.68	.86	NA[d]	NA[d]	.11	.49	NA[d]
Cervical										
Anterior C1 mandible	641	468 (73)	.18	.43	.41	.32	.44	.91	.13	.73
Anterior C1 transverse process	406	252 (62)	.51	.74	.19	.07	.06	.36	.81	.50
Anterior C2-C6	652	535 (82)	.27	.80	.31	.61	.29	.57	.17	.90
Anterior C7	620	244 (39)	.09	.30	**.01 (↑)**	.17	.64	**.003 (Pain)**	.99	.75
Anterior C8	615	245 (40)	.38	.52	**<.001 (↑)**	.12	.69	.67	.15	.55
Posterior C1 inion (right/left)	422	84 (20)	.57	.58	.92	**.03 (O>W,A)**	.28	.87	.19	.86
Posterior C1 inion (midline)	324	45 (14)	**.005 (F>M)**	.94	.14	.19	.33	.13	.38	.97
Posterior C1 lateral occiput	583	261 (45)	**.02 (F>M)**	.67	.96	.94	**.02 (Pain)**	**.02 (Pain)**	**<.001 (Pain)**	.21
Posterior C2 lateral occiput	564	196 (35)	.07	.81	.94	.68	.06	**.02 (Pain)**	.17	.81
Posterior C1-C7 (right/left)	618	366 (59)	**.02 (F>M)**	.35	.19	.94	.10	.33	.16	.12
Posterior C1-C7 (midline)	503	238 (47)	.54	.60	.96	.79	.22	.76	.31	**.04 (No)**
Posterior C8 medial (right/left)	478	50 (10)	**.03 (F>M)**	.83	.75	.10	.97	.82	.92	.54
Posterior C8 medial (midline)	366	38 (10)	**.02 (F>M)**	.52	.13	.59	.30	.78	.65	.74
Posterior C8 lateral	360	71 (20)	.45	.60	.67	.09	**.01 (Pain)**	.69	.19	.63
Thoracic										
Anterior T1-T6 midline	674	520 (77)	**<.001 (F>M)**	.95	.15	**.02 (A>W,O)**	.82	.50	.44	.96
Anterior T7-T11 midline	326	73 (22)	.06	.99	.06	.48	.58	.35	.33	.60
Anterior T7-T11 lateral	654	380 (58)	.35	.48	.20	.93	**.049 (Pain)**	**<.001 (Pain)**	.07	.62
Anterior T12 iliac crest	611	302 (49)	.51	.67	.08	.81	.12	.57	.33	.59
Posterior T1-T12 midline spinous process	780	391 (50)	.96	.83	.89	.97	.35	**.04 (Pain)**	.73	.17
Posterior T1-T12 inferolateral spinous process	780	465 (60)	.29	.85	.51	.22	.97	.15	.65	.64
Posterior T1-T12 transverse process	739	471 (64)	.15	.64	.42	.69	**.007 (No)**	.58	>.99	.53

(continued)

[a] Statistically significant findings appear in **boldface**.
[b] Age groups: 20-25, 26-30, and 31-50 years.
[c] Race groups: white (W), Asian (A), and other (O).
[d] Insufficient variation in independent variable (ie, almost all students surveyed were homogeneous).
[e] 2 race categories (white, all others).
[f] 2 age categories (20-25, 26-50).

Abbreviations: F, female; HIFO, high ilium flare out; HISI, high ilium sacroiliac; M, male; MPSI/FISI, midpole sacroiliac/flare in sacroiliac; N, number of surveys with all demographic and medical history variables included; No, increased probability with no pain/trauma; Pain, increased probability with history of pain; Tr, increased probability with history of trauma; ↑, increased probability with increased weight; ↓, decreased probability with increased weight.

eTable 2 *(continued)*.
Multiple Logistic Regression Model Predicting Probability of Surveyed Osteopathic Medical Students Having Positive Tender Points Based on Characteristics

Tender Point Group by Body Area	N	Positive Tender Points	*P* Values[a] Sex	Age[b]	Weight	Race[c]	Pain Current	Pain Intermittent	Pain Chronic	Trauma
Ribs										
Anterior R1-R6	633	590 (93)	**.005 (F>M)**	.59	.21	.78	NA[d]	.63	NA[d]	.09
Anterior R2 lateral	274	179 (65)	.59	.84	.54	.27	.39	.52	.15	.60
Anterior R2 medial	272	202 (74)	.45	.36	.67	.32	NA[d]	.60	.27	.51
Anterior R7-R10	278	165 (59)	**<.001 (F>M)**	.25	**.001 (↑)**	.22	NA[d]	.85	.66	.81
Posterior R1-R6	616	548 (89)	.99	.75	**.03 (↓)**	.51	.77	**.03 (No)**	NA[d]	.30
Posterior R7-R10	271	126 (46)	.08	**.01 (20-25>26-30)**	**.003 (↑)**	.12	.24	.63	.24	.37
Lumbar										
Anterior L1	648	305 (47)	.55	**.002 (20-25>26-30, 31-50)**	.07	.19	.17	**.001 (Pain)**	**.01 (Pain)**	.81
Anterior L2	658	397 (60)	.23	.98	.13	.28	.81	.11	.42	.56
Anterior L3	640	262 (41)	.73	**.02 (20-25>26-30, 31-50)**	.84	**.05 (A>W,O)**	.36	**.006 (Pain)**	.46	**.04 (Tr)**
Anterior L4	650	285 (44)	.10	.93	.73	.60	.32	**.005 (Pain)**	**.01 (Pain)**	.51
Anterior L5	666	455 (68)	.12	.19	.10	.44	.17	**<.001 (Pain)**	**.02 (Pain)**	.59
Posterior L1-L5 midline spinous process	718	226 (31)	.12	.42	.19	.39	.43	.82	.21	**.05 (Tr)**
Posterior L1-L5 inferolateral spinous process	718	270 (38)	**.04 (F>M)**	.78	.13	.24	.26	.33	.73	.41
Posterior L1-L5 transverse process	688	289 (42)	.30	.20	.80	.47	.93	.10	.39	**.02 (Tr)**
Posterior L3-L4 lateral (gluteus medius)	572	359 (63)	.09	**.049 (26-30, 20-25> 31-50)**	**.03 (↓)**	.66	.36	.11	**.01 (Pain)**	**.04 (No)**
Upper pole L5	564	161 (29)	**<.001 (F>M)**	.69	.13	**.03 (O,A>W)**	.68	**<.001 (Pain)**	**.02 (Pain)**	.06
Lower pole L5	556	251 (45)	**.01 (F>M)**	.16	.74	.14	.82	**<.001 (Pain)**	**.04 (Pain)**	.28
Pelvis/Sacrum										
Iliacus (iliopsoas/psoas)	521	329 (63)	.86	.16	.80	.94	.61	.78	.24	.60
Iliacus	83	63 (76)	.70	.45	.30	.32	.60	.55	.86	.25
Psoas	84	40 (48)	.44	.53	.08	.97	.66	.38	.28	.52

(continued)

[a] Statistically significant findings appear in **boldface**.
[b] Age groups: 20-25, 26-30, and 31-50 years.
[c] Race groups: white (W), Asian (A), and other (O).
[d] Insufficient variation in independent variable (ie, almost all students surveyed were homogeneous).
[e] 2 race categories (white, all others).
[f] 2 age categories (20-25, 26-50).

Abbreviations: F, female; HIFO, high ilium flare out; HISI, high ilium sacroiliac; M, male; MPSI/FISI, midpole sacroiliac/flare in sacroiliac; N, number of surveys with all demographic and medical history variables included; No, increased probability with no pain/trauma; Pain, increased probability with history of pain; Tr, increased probability with history of trauma; ↑, increased probability with increased weight; ↓, decreased probability with increased weight.

eTable 2 *(continued)*.
Multiple Logistic Regression Model Predicting Probability of Surveyed Osteopathic Medical Students Having Positive Tender Points Based on Characteristics

Tender Point Group by Body Area	N	Positive Tender Points	*P* Values[a]							
							Pain			
			Sex	Age[b]	Weight	Race[c]	Current	Intermittent	Chronic	Trauma
Pelvis/Sacrum *(continued)*										
Inguinal (pectineus)	440	310 (70)	.35	.16	.55	.70	.18	.07	**.04 (Pain)**	.39
Gluteus minimus	269	108 (40)	.16	.41	.65	.22	.47	.20	.70	.65
Low ilium	94	57 (61)	.86	.35	.89	.52	.29	**.01 (Pain)**	.21	.16
Piriformis (PIR)	459	258 (56)	.08	.43	.30	.48	.84	.14	.18	.93
High ilium (HISI)	498	215 (43)	.06	.27	.41	.44	.49	**<.001 (Pain)**	**.05 (Pain)**	.58
Gluteus maximus (MPSI/FISI)	421	188 (45)	**.003 (F>M)**	.07	.83	.17	.48	.16	**.02 (Pain)**	.18
Coccygeus (HIFO)	436	102 (23)	.48	.20	.94	.24	>.99	.06	**.02 (Pain)**	.59
Upper Extremity										
Supraspinatus	410	249 (61)	.21	.51	.60	.18	.62	.10	.86	.68
Infraspinatus	409	249 (61)	**<.001 (F>M)**	.33	.10	.85	.69	.36	**.02 (Pain)**	.90
Infraspinatus lateral	407	182 (45)	**.002 (F>M)**	.55	.34	.88	.94	.13	**.049 (Pain)**	.60
Infraspinatus medial	405	161 (40)	**<.001 (F>M)**	.24	**.03 (↑)**	.76	.41	.57	.09	.92
Subscapularis	408	268 (66)	**.006 (F>M)**	.76	**.008 (↑)**	.87	.34	.61	.63	.38
Levator scapulae	409	294 (72)	.29	.93	.89	.51	.07	.26	.67	.85
Biceps—long head	422	229 (54)	.23	.37	.96	.32	.71	**.02 (Pain)**	.74	.43
Biceps—short head (coracobrachialis)	415	223 (54)	.46	.57	.29	.84	.82	.34	.43	.37
Latissimus dorsi	93	57 (61)	.67	.12	.81	.83	.19	.59	.15	.28
Radial head (supinator)	415	276 (67)	.07	.68	.23	.81	.48	.16	.99	.55
Triceps (lateral olecranon)	268	146 (54)	.22	.32	.64	.30	NA[d]	.34	.76	.59
Pronator (medial epicondyle)	418	197 (47)	.97	.20	.50	.73	.62	.66	.69	.90
Palmar wrist (flexor carpi radialis/ ulnaris and flexor digitorum superficialis and profundus)	365	121 (33)	.26	.49	.70	.43	.22	.74	.48	**.05 (Tr)**
Palmar wrist (flexor carpi radialis/ulnaris)	265	88 (33)	.17	.94	.86	.51	.33	.72	.31	.28

(continued)

[a] Statistically significant findings appear in **boldface**.
[b] Age groups: 20-25, 26-30, and 31-50 years.
[c] Race groups: white (W), Asian (A), and other (O).
[d] Insufficient variation in independent variable (ie, almost all students surveyed were homogeneous).
[e] 2 race categories (white, all others).
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Abbreviations: F, female; HIFO, high ilium flare out; HISI, high ilium sacroiliac; M, male; MPSI/FISI, midpole sacroiliac/flare in sacroiliac; N, number of surveys with all demographic and medical history variables included; No, increased probability with no pain/trauma; Pain, increased probability with history of pain; Tr, increased probability with history of trauma; ↑, increased probability with increased weight; ↓, decreased probability with increased weight.

eTable 2 (*continued*).
Multiple Logistic Regression Model Predicting Probability of Surveyed Osteopathic Medical Students Having Positive Tender Points Based on Characteristics

Tender Point Group by Body Area	N	Positive Tender Points	*P* Values[a]							
							Pain			
			Sex	Age[b]	Weight	Race[c]	Current	Intermittent	Chronic	Trauma
Palmar wrist (flexor digitorum superficialis and profundus)	100	33 (33)	.22	**.03 (26-30>20-25)**	.11	.82	NA[d]	.94	.69	.28
Dorsal wrist	102	22 (22)	.06	.83	.12	.65	NA[d]	.40	.55	.86
First carpometacarpal (abductor pollicis brevis)	270	184 (68)	.66	.54	.85	.40	.88	.24	.23	.60
Extensor digitorum	47	9 (19)	**.04 (F>M)**	.42	.12	.19[e]	NA[d]	.56	.78	.11
Flexor pollicis brevis	46	10 (22)	**.048 (M>F)**	.71	.13	.74	NA[d]	.45	.34	NA[d]
Lower extremity										
Lateral trochanter	487	302 (62)	**.01 (F>M)**	.16	.92	.95	.82	**.03 (Pain)**	.34	.25
Posterior lateral trochanter	347	234 (67)	**.01 (F>M)**	**.03 (20-25>26-30)**	.61	.31	.83	**.03 (Pain)**	.12	.09
Posterior medial trochanter	80	39 (49)	.06	.55	.48	.49	.58	.56	.22	.70
Cruciate/hamstring/ popliteus	463	362 (78)	.55	.75	.10	.30	.22	.11	.62	.43
Cruciate (anterior and posterior)	157	87 (55)	.06	.60	.07	.22	.75	.58	.74	.30
Hamstring (medial and lateral)	461	335 (73)	.31	.51	**.02 (↑)**	.27	.10	.11	.29	.82
Popliteus	33	12 (36)	.28	.81	.57	.85	NA[d]	.49	.53	.09
Medial meniscus	338	202 (60)	**<.001 (F>M)**	.23	**.05 (↑)**	.10	.26	.67	.09	.93
Lateral meniscus	335	152 (45)	**<.001 (F>M)**	.87	.21	.77	.50	.31	**.05 (Pain)**	.90
Patellar	99	27 (27)	.13	.62[f]	.59	.78	.33	.63	.69	.16
Flexion calcaneus (quadratus plantae)	452	175 (39)	.14	.22	.32	.54	.46	.33	**.02 (Pain)**	.21
Medial calcaneus (abductor hallucis)	308	175 (57)	.67	.58	.74	.45	.30	.99	**.006 (Pain)**	.53
Lateral ankle (peroneus longus and brevis)	451	318 (71)	.16	.10	.41	.52	.13	**.001 (Pain)**	.22	.22
Extension ankle (gastrocnemius and soleus)	458	359 (78)	**.02 (F>M)**	**.03 (20-25>31-50)**	.19	.74	.13	.08	**.02 (Pain)**	.88
Medial ankle	158	88 (56)	.98	.08	.18	.58	.66	.25	.07	.76
Navicular	256	209 (82)	.20	.83	.11	.53	.12	**.04 (Pain)**	**.04 (Pain)**	.55

[a] Statistically significant findings appear in **boldface**.
[b] Age groups: 20-25, 26-30, and 31-50 years.
[c] Race groups: white (W), Asian (A), and other (O).
[d] Insufficient variation in independent variable (ie, almost all students surveyed were homogeneous).
[e] 2 race categories (white, all others).
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Abbreviations: F, female; HIFO, high ilium flare out; HISI, high ilium sacroiliac; M, male; MPSI/FISI, midpole sacroiliac/flare in sacroiliac; N, number of surveys with all demographic and medical history variables included; No, increased probability with no pain/trauma; Pain, increased probability with history of pain; Tr, increased probability with history of trauma; ↑, increased probability with increased weight; ↓, decreased probability with increased weight.