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ORIGINAL ARTICLE

Tumor imaging instruction and assessment at chiropractic colleges in North America: a pilot study with implications for National Board of Chiropractic Examiners content

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Objective: This pilot study tested a survey instrument pertaining to the instruction and assessment of tumor imaging in chiropractic training programs. The secondary purpose was to gather data regarding credentials of lead instructors, textbook and resource use, and tumors taught and assessed.
Methods: An electronic survey was distributed to lead tumor imaging instructors at all chiropractic colleges in the United States and Canada. A focus group of tumor imaging instructors was conducted to clarify ambiguous data.
Results: Diplomate status with the American Chiropractic Board of Radiology was held by 87.5% of the instructor respondents. There were similarities in course content and assessment across institutions. A total of 26 tumors were considered clinically significant by more than 65% of instructors, 9 tumors were identified as not clinically significant by more than 65%, and 4 tumors were considered clinically significant by 35% to 65% of instructors. There was correlation between those instructors who evaluated on various tumors and those who feel it is important to evaluate such tumors ($r_S = 0.94$, $p < .001$). The focus group addressed the 4 equivocal tumors and recommended 3 be added to the list of clinically insignificant tumors.
Conclusion: The survey instrument is ready to be used to conduct a study of all clinical areas of the chiropractic curriculum. A total of 12 tumors were recommended for removal from National Board of Chiropractic Examiners tests. The authors recommend that the Academics Committee of the American Chiropractic Board of Radiology share information regarding learning libraries to allow for a richer learning experience across all campuses.

Key Indexing Terms: Diagnostic Imaging; Radiology; Chiropractic; Education

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INTRODUCTION

Chiropractic programs are required to be a minimum of 4200 hours[1] in length and, as in most health care professions, the chiropractic curriculum is challenging. Students spend up to 35 hours a week in the classroom.[2–6] Students experience stress for many reasons, such as financial issues, fatigue, length of time in the program, and stress levels have been linked to sex.[2,3] Students are required to pass high stakes exams to obtain licensure. Uncertainty as to the content of the exams adds to their stress. Faculty struggle with deciding what should be taught in the classroom to produce the best chiropractic graduate. "However, a dearth of literature exists examining how radiology is taught, learned, or evaluated."[4] The overriding issue that guides most instructors is whether material is clinically important for students to master. It is important to remain focused on the needs of the students and what they should know to practice competently.[5] A complicating factor is whether the content is tested on the licensing exam given by the National Board of Chiropractic Examiners (NBCE).

Faculty members often can be heard saying, "I only teach this because it's on the boards." This begs the question, is the content that is tested on the NBCE clinically relevant in today's healthcare environment? The test writing committees of the NBCE are comprised of content experts currently teaching the associated material and representatives recommended by the chiropractic schools. In addition, schools are invited to submit questions and some schools participate more than others.[7] However, the questions created are required to follow the test plan outlined by the NBCE,[7] even if the test plan includes topics college faculty otherwise would not teach students. Passing the NBCE exam is a requirement for chiropractic graduates to obtain licensure in the United States. In addition, NBCE scores are reviewed by accreditors as one indication of students' competency.[1]

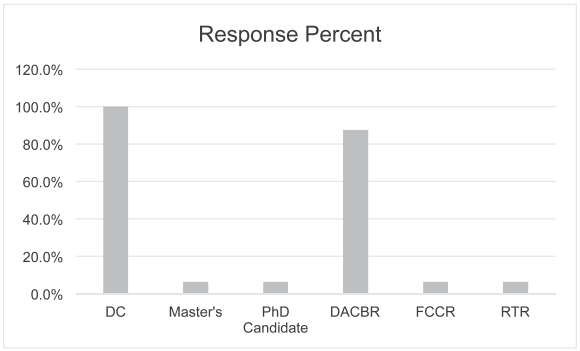

Figure 1 - Credentials of primary instructors of Tumor Imaging at Chiropractic Colleges in the US and Canada. DC, doctor of chiropractic; DACBR, diplomate of the American Chiropractic Board of Radiologists; FCCR, Fellow of Chiropractic College of Radiologists; RTR, registered technologist radiology

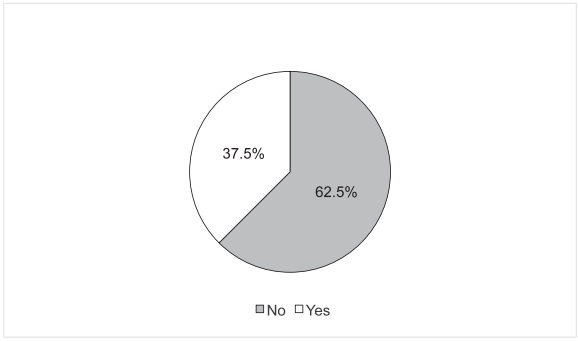

Figure 2 - Instructors that correlate students' course performance with NBCE results.

Authors from various health care fields have published that students' grade point averages correlate with passing board rates.[8–13] While we know that students who are more successful in their academics perform better on board exams, it still is very important to make sure that, where possible, clinically relevant material is being tested on licensure examinations. This pilot survey seeks to become the starting process for an ongoing, more detailed survey project.

The decision of an instructor as to what content to include in his/her course, how to teach the material, and the available resources depends on many variables and may differ from school to school.[10,11,14] In a chiropractic curriculum, NBCE content has an important part in this decision. Depending on the school and instructor, the importance placed on the material as related to the NBCE content may vary.

The perception that the material will be clinically important is the major factor in determining content. Field doctors may differ in the perspective of what should be taught in the curriculum.[5,15] Variability in the curriculum between institutions is inevitable. However, once common content issues are determined, then it is possible that external examining agencies will be responsive to the information.

What is taught and what is assessed often differ. Instructors tend to assess the material they think is important. This pilot survey sought to test a survey instrument designed to gather data necessary to answer these questions in regard to clinical content within curricula. The pilot was targeted to the instruction and assessment of tumor imaging in chiropractic programs.

The primary purpose of this pilot study was to test the instrument and, secondarily, to gather data regarding the credentials of lead instructors of tumor imaging, textbook and resource use, what tumors are taught, why they are taught, how they are taught, and which tumors are assessed along with how they are assessed at the chiropractic colleges in the United States and Canada. This initial study will lead to a comprehensive survey study examining these factors throughout the clinical curriculum at chiropractic colleges.

METHODS

Study Design

Following approval by the institutional review board of D'Youville College, an electronic survey consisting of 133 questions was designed to gather data necessary to answer the research questions. The survey was reviewed and pretested by 2 chiropractic radiologists, and their feedback was incorporated into the instrument. Primary skeletal tumors were selected as the curricular area for the pilot study due to the ease of identifying lead instructors in this curricular area.

The survey then was distributed through SurveyMonkey (SurveyMonkey Inc, San Mateo, CA) to the lead instructor for the tumor imaging course(s) at each of the 20 chiropractic colleges in the United States and Canada. Lead instructors were identified through either the American Association of Chiropractic Radiologists Academic Committee or the chief academic officers and/or department heads at each institution. Confirmation of lead instructor status was confirmed as part of the survey questions. These individuals were asked to complete the survey and to provide feedback about the survey instrument to the primary investigator. The list of primary bone tumors was taken directly from the textbook *Essentials of Skeletal Radiology*[16] chapter on tumors and tumor-like processes.

Data Analysis

The normality assumption for Pearson's correlation was not met, so Spearman's rank-order correlations were calculated using IBM SPSS Statistics 20 (IBM Corporation, Armonk, NY) to analyze if instructors assessed more frequently items that they viewed as clinically important than items they did not believe to be clinically important, and the percent that assessed tumor knowledge using written evaluations versus those who assessed tumor knowledge using imaging evaluations. A focus group of respondents was conducted on October 24, 2015 at the annual meeting of the American College of Chiropractic Radiologists. The focus group discussed the merits of the 4

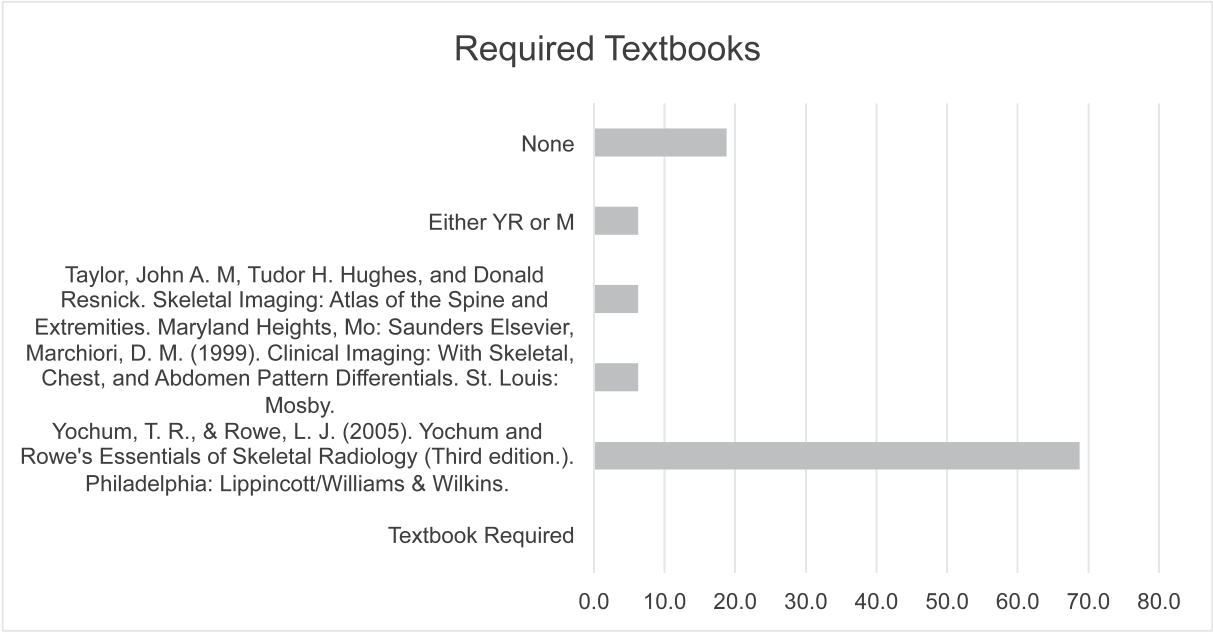

Figure 3 - Required textbooks for tumor imaging.

equivocal tumors (chordoma, parosteal sarcoma, intraosseous lipomas, and fibrosarcomas) with regard to appropriateness of inclusion in curricula and assessment within curricula and on NBCE.

RESULTS

Of the 20 surveys distributed, 16 were completed for an 80% response rate. The feedback on the survey instrument resulted in the elimination of an entire subset of questions regarding time spent on topics in the classroom and laboratory. Of the respondents, 16 (100%) possessed DC degrees and 14 (87.5%) held diplomate status with the American Chiropractic Board of Radiology (Fig. 1). Ten (62.5%) of the respondents correlated student course performance with NBCE results (Fig. 2).

Regarding required textbooks, 11 (68.8%) instructors required *Essentials of Skeletal Radiology,*[16] 1 (6.3%) required *Clinical Imaging: with Skeletal, Chest and Abdomen Pattern Differentials,*[17] and 1 (6.3%) required *Skeletal Imaging: Atlas of the Spine and Extremities*.[18] Five instructors did not require a specific textbook. Of these, 2 recommend either *Essentials of Skeletal Radiology*[16] or *Clinical Imaging: with Skeletal, Chest and Abdomen Pattern Differentials*.[17] One instructor (6.3%) recommended *Skeletal Imaging: Atlas of the Spine and Extremities,*[18]

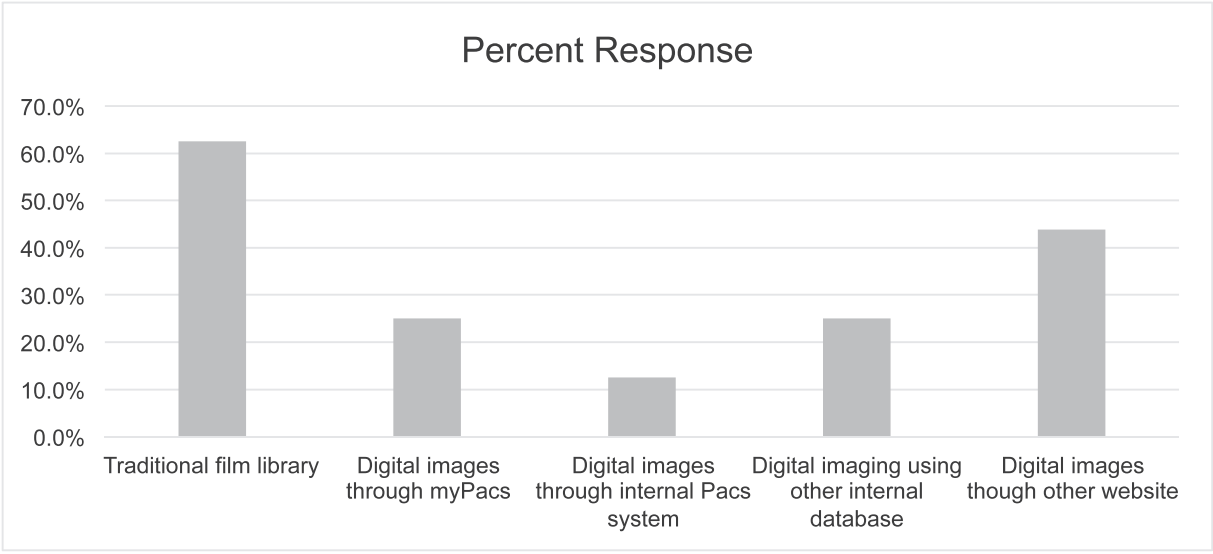

Figure 4 - Laboratory learning library format.

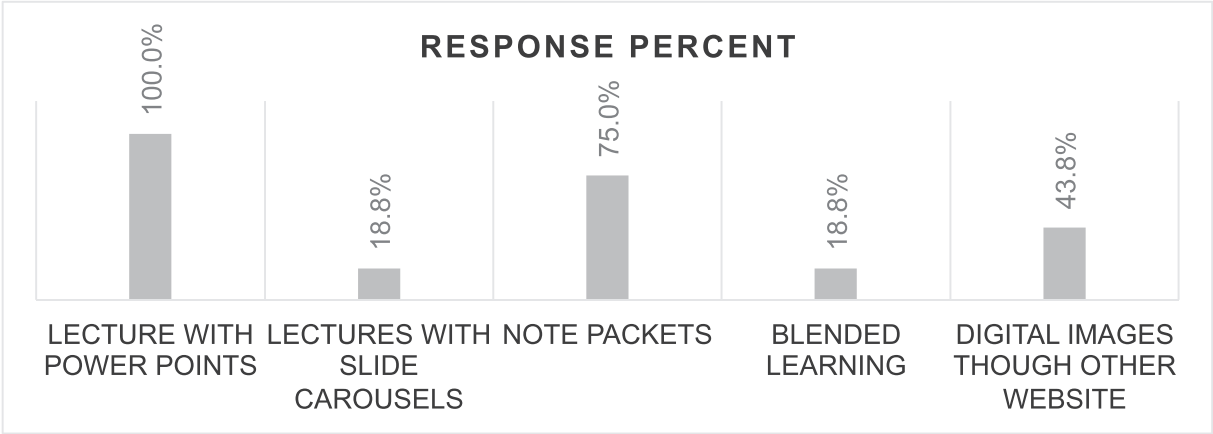

Figure 5 - Lecture teaching styles and tools used.

but found most students still purchased *Essentials of Skeletal Radiology*[16] as students perceived it to be better for board preparation. The remaining instructor (6.3%) did not recommend a textbook at all and used course notes exclusively (Fig. 3).

All respondents reported providing a learning library of images for students. Of these, 10 (62.5%) used traditional plain film, 4 (25%) used the website myPacs, 2 (12.5%) used an internal database, 6 (37.5%) reported using other websites (Fig. 4.), and 1 (6.3%) used American College of Radiology (ACR) CD-ROMS. Other websites reported were radiopedia.org, radiology masterclass, images.google.com, Radiological Society of North America Medical Imaging Resource Community, auntminie.com, and bone-tumor.org.

Traditional in-class lectures using PowerPoint (Microsoft Corp, Redmond, WA) presentations were used by 16 (100%) of the instructors with 3 (18.75%) also using traditional slide carousels. Note packets were provided by 12 instructors (75%) and 3 (18.75%) used a blended learning approach to the course (Fig. 5). Individual respondents also reported using online resources through the college learning management system and the use of lecture capture. Laboratory instruction was not as uniform across the institutions with 10 (62.5%) using traditional plain film, 4 (25%) using PACS based/digital film laboratories, and 3 (18.75%) using an online teaching website. Similarly, the method of instruction varied among instructors with 9 (56.25%) using a "hot seat" approach, 5 (31.25%) requiring students to work through cases on their own while the instructor is available for questions, 5 (31.25%) using self-assessments, and 2 (12.5%) preferring a blended learning approach in the laboratory (Fig. 6). One institution did not offer laboratories for radiology pathology courses.

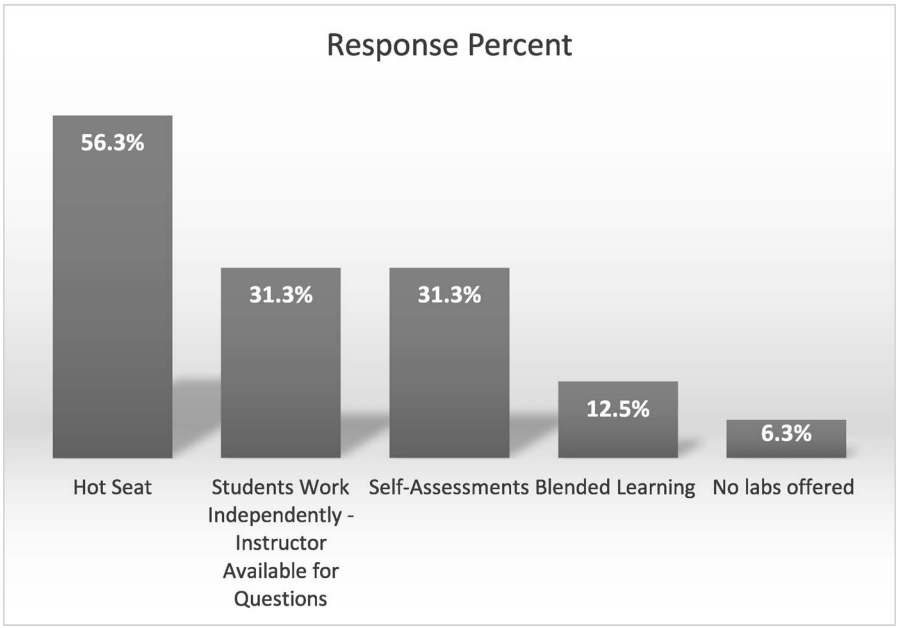

Figure 6 - Lab teaching style.

Table 1 - Tumors Considered Clinically Important by Respondents

Tumor	# Respondents	% Teach as Clinically Important
Tumors considered clinically important by more than 65% of respondents		
Aneurysmal bone cyst	16	100.00
Bone islands	16	100.00
Ewing's sarcoma	16	100.00
Fibrous dysplasia	16	100.00
Fibrous xanthoma of bone: fibrous cortical defects	14	100.00
Fibrous xanthoma of bone: NOF	16	100.00
Giant cell tumor	16	100.00
Hemangiomas	16	100.00
Multiple myeloma	16	100.00
Osteoid osteomas	16	100.00
Paget's disease	16	100.00
Solitary enchondroma	16	100.00
Solitary osteochondroma	16	100.00
Central osteosarcoma	16	93.75
Chondrosarcoma	16	93.75
Hereditary multiple exostoses	16	93.75
Secondary osteosarcoma	16	93.75
Simple bone cysts	16	93.75
Solitary plasmacytoma	16	93.75
Chondroblastoma	16	87.50
Osteoblastomas	16	87.50
Multiple enchondromatosis	16	81.25
Neurofibromatosis	16	81.25
Non-Hodgkin's lymphoma of bone	16	81.25
Osteomas	16	75.00
Hodgkin's lymphoma of bone	16	68.75
Tumors considered clinically important by between 35%–65% of respondents		
Chordomas	16	62.50
Parosteal sarcoma	16	50.00
Intraosseous lipomas	16	43.80
Fibrosarcoma	16	37.50
Tumors considered clinically important by less than 35% of respondents		
Extraosseous osteosarcoma	15	26.70
Multicentric osteosarcoma	16	25.00
Gardner's syndrome	16	18.80
Maffucci's syndrome	16	18.80
Synovial sarcoma	16	18.80
Chondromyxoid fibroma	15	13.30
Neuroblastoma	16	12.50
Adamantinoma	15	0.00
Periosteal chondroma	16	0.00

The respondents identified the majority of primary bone tumors as being clinically important and that they would teach them regardless of NBCE examination content. The tumors that were considered clinically important by more than 65% (11/16) of the respondents are presented in Table 1. Tumors found to be less clinically relevant were assessed infrequently or never. Table 2 shows tumors assessed by <60% of instructors and those assessed by >60% of instructors. The Table also indicates if the assessments are through written examinations that do not use radiographic images or through examinations that use radiographic images of the pathology.

A monotonic association was found with the Spearman's correlation between how clinically relevant a tumor was considered and how frequently it was assessed among instructors ($r_s = 0.94$, $p < .001$). There also was correlation for the percent who evaluated using written evaluations versus percent who thought the tumor was important ($r_s = 0.91$, $p < .001$) and the percent who evaluated using imaging evaluations versus the percent who thought the tumor was important ($r_s = 0.95$, $p < .001$).

The focus group unanimously believed that parosteal sarcomas, intraosseous lipomas, and fibrosarcomas should not be assessed within curricula or on NBCE examinations. One individual (16.7%) believed that chordomas should be assessed within the curricula and on NBCE examinations. These findings were supported by the data that less than 60% of instructors were assessing parosteal sarcoma, intraosseous lipomas, and fibrosarcomas, but chordomas were assessed by more than 60% of instructors.

DISCUSSION

It is apparent from the results that there is a significant amount of standardization across the chiropractic institutions in the United States and Canada in regard to instructing tumor imaging. The standard credentials for instructing tumor imaging at chiropractic colleges in the United States and Canada is a DC degree and a Diplomate of the American Chiropractic Board of Radiology. It also is evident that the majority of instructors for tumor imaging do not correlate their student course performance with NBCE results. The majority of instructors (81.3%) required a diagnostic imaging textbook in their courses, with the most common textbook being Yochum and Rowes' *Essentials of Skeletal Radiology*.[16] Similarly, all colleges provide students with a learning library of images for learning to interpret radiographs. However, there was little consistency in the format of the learning library with 62.5% still using traditional plain film images, 37.5 % using internal digital databases/internal PACS system, 62.5% using a variety of internet websites, and one college using ACR CD-ROMs.

The majority of the primary bone tumors are considered clinically significant by the majority of lead bone tumor instructors at chiropractic colleges. Accordingly, students are assessed on their mastery of the information and their clinical radiographic interpretation skills on these primary

Table 2 - Tumors Assessed by Instructors

Tumor	# Respondents	% Assess	% Written Assessments	% Imaging Assessments
Tumors assessed by more than 60% or more of instructors				
Aneurysmal bone cyst	16	100.0	87.5	100.0
Bone islands	16	100.0	87.5	100.0
Chondrosarcoma	16	100.0	87.5	100.0
Ewing's sarcoma	16	100.0	87.5	100.0
Fibrous dysplasia	16	100.0	87.5	100.0
Fibrous xanthoma of bone: fibrous cortical defects	15	100.0	86.7	100.0
Fibrous xanthoma of bone: NOF	16	100.0	87.5	100.0
Giant cell tumor	16	100.0	87.5	100.0
Hemangiomas	16	100.0	81.3	100.0
Hereditary multiple exostoses	16	100.0	87.5	100.0
Multiple enchondromatosis	16	100.0	81.3	81.3
Multiple myeloma	16	100.0	93.8	100.0
Osteoid osteomas	16	100.0	87.5	100.0
Paget's disease	16	100.0	87.5	100.0
Simple bone cysts	16	100.0	87.5	100.0
Solitary enchondroma	16	100.0	87.5	100.0
Solitary osteochondroma	16	100.0	87.5	100.0
Central osteosarcoma	16	93.7	75.0	100.0
Chondroblastoma	16	93.7	81.3	93.8
Osteoblastomas	16	93.7	81.3	93.8
Solitary plasmacytoma	16	93.7	68.8	100.0
Hodgkin's lymphoma of bone	16	87.5	75.0	75.0
Neurofibromatosis	16	87.5	75.0	68.8
Non-Hodgkin's lymphoma of bone	16	87.5	75.0	87.5
Secondary osteosarcoma	16	87.5	62.5	81.3
Osteomas	16	81.2	75.0	68.8
Chordomas	15	80.0	66.7	73.3
Fibrosarcoma	15	60.0	60.0	33.3
Maffucci's syndrome	15	60.0	53.3	40.0
Tumors assessed by less than 60% of instructors				
Intraosseous lipomas	15	40.0	26.7	33.3
Gardner's syndrome	14	35.7	35.7	7.1
Parosteal sarcoma	16	31.2	25.0	31.3
Chondromyxoid fibroma	15	26.7	20.0	20.0
Extraosseous osteosarcoma	15	26.7	20.0	6.7
Multicentric osteosarcoma	14	21.4	21.4	21.4
Neuroblastoma	15	20.0	20.0	6.7
Synovial sarcoma	14	7.1	0.0	7.1
Adamantinoma	13	0.0	0.0	0.0
Periosteal chondroma	14	0.0	0.0	0.0

tumors. It is appropriate that these tumors be evaluated by NBCE in determining competency of graduates.

It is recommended that the tumors that are taught and/or assessed by less than 35% of instructors should be dropped by NBCE as potential examination questions and distractors as they are not considered clinically significant by the majority of content experts that instruct chiropractic students. Accordingly, chiropractic students are not expected to master this material in their diagnostic imaging classes. If NBCE removes all reference to these tumors, instructors would be able to stop teaching these tumors in chiropractic colleges to already overburdened students. The tumors that should be eliminated are: adamantinoma, chondromyxoid fibroma, extraosseous osteosarcoma, fibrosarcoma, Gardner's syndrome, intraosseous lipomas, Maffucci's syndrome, multicentric osteosarcoma, neuroblastoma, parosteal sarcoma, periosteal chondroma, and synovial sarcoma.

This study was limited to primary bone tumors to test the survey instrument. A comprehensive project to evaluate curricula across the chiropractic programs in the United States and Canada will be expanded to all areas of the chiropractic curriculum from this pilot study.

CONCLUSION

The 12 tumors taught and/or assessed by less than 35% of instructors should be removed from all NBCE

examinations as they are neither taught nor evaluated in the majority of chiropractic programs in the United States and Canada, as they are not considered clinically important by the content experts teaching the courses. The authors recommend that the academics committee of the ACBR share information regarding learning libraries to allow for a richer learning experience across all campuses. The survey instrument is ready to be used to conduct a study of all clinical areas of the chiropractic curriculum.

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REFERENCES

1. The Council on Chiropractic Education. CCE Accreditation Standards Principles, Processes & Requirements for Accreditation. Scottsdale: The Council; 2013. Available from: http://www.cce-usa.org/uploads/2013_CCE_ACCREDITATION_STANDARDS.pdf.
2. Kizhakkeveettil A, Vosko AM, Brash M, Philips MA. Perceived stress and fatigue among students in a doctor of chiropractic training program. *J Chiropr Educ*. 2016; 31:8–13.
3. Hester H, Cunliffe C, Hunnisett A. Stress in chiropractic education: a student survey of a five-year course. *J Chiropr Educ*. 2013;27(2):147–151.
4. Linaker KL. Radiology undergraduate and resident curricula: a narrative review of the literature. *J Chiropr Humanit*. 2015;22(1):1–8.
5. Bhogal P, Booth TC, Phillips AJ, Golding SJ. Radiology in the undergraduate medical curriculum – who, how, what, when, and where? *Clin Radiol*. 2012; 67(12):1146–1152.
6. Quintero G. Medical education and the healthcare system why does the curriculum need to be reformed? *BMC Med*. 2014;12:213.
7. National Board of Chiropractic Examiners [homepage on the Internet]. Greely: National Board of Chiropractic Examiners; 2015 [cited 2015 Sept 2]. Available from: http://mynbce.org/prepare/exam_develop/.
8. Lawson DM, Till H. Predictors of performance of students from the Canadian Memorial Chiropractic College on the licensure examinations of the Canadian Chiropractic Examining Board. *J Manipulative Physiol Ther*. 2006;29(7):566–569.
9. McCall AR, Harvey RD. Predictors of performance on the National Board of Chiropractic Examiners Parts I and II. *J Chiropr Educ*. 2014;28(1):9–15.
10. Kapoor N, Smith SE. Association between medical school radiology curricula and application rates to US radiology residency programs. *JACR J Am Coll Radiol*. 2014;11(11):1064–1068.
11. Boissonnault WG, White DM, Carney S, Malin B, Smith W. Diagnostic and procedural imaging curricula in physical therapist professional degree programs. *J Orthop Sports Phys Ther*. 2014;44(8):579–586.
12. Kalthoff TJ. National Board Scores versus student GPAs in chiropractic education. *Coll Univ*. 1985;61(1): 61–67.
13. Wolfenberger V. Correlations between chiropractic National Board (part I) scores and basic science course grades and related data. *Coll Univ*. 1999;74(2):16–20.
14. Willatt JMG, Mason AC. Comparison of radiology residency programs in ten countries. *Eur Radiol Eur Radiol*. 2006;16(2):437–444.
15. Subramaniam RM, Sherriff J, Holmes K, Chan MC, Shadbolt B. Radiology curriculum for medical students: clinicians' perspectives. *Australas Radiol*. 2006; 50(5):442–446.
16. Yochum TR, Rowe LJ. *Essentials of Skeletal Radiology*. Philadelphia: Lippincott, Williams and Wilkins; 2005.
17. Marchiori DM. *Clinical Imaging: With Skeletal, Chest, & Abdominal Pattern Differentials*, 3rd ed. St. Louis: Mosby; 2013.
18. Taylor J, Hughes T, Resnick D. *Skeletal Imaging: Atlas of the Spine and Extremities*, 2nd ed. Maryland Heights [MO]: Saunders; 2009.