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| <u>Design</u> (planned the methods to generate the results)                                                                 | REAH; BFW; KJY                                                                                                                                                                                 |
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**Abstract**

**Objective:** The purpose of this paper was to investigate the current utilization of MSK-DUSI at chiropractic programs worldwide and to elicit opinions of academic diagnostic imaging staff of its prospective use at their teaching institution.

**Methods:** An electronic questionnaire was designed using SurveyMonkey and notifications were disseminated by email to diagnostic imaging staff at chiropractic programs worldwide. Recruitment used a modified Dillman method over the course of nine weeks in mid-2014. The questionnaire consisted of 27 items using multiple-choice, Likert-type and open-ended questions. Descriptive statistics were used for basic demographic data and the results of the numerical scales used in each item.

Results: 59 (59/127) respondents from 24 (24/41) chiropractic programs returned questionnaires. The current utilization of MSK-DUSI at chiropractic programs is low (n = 5/24), however respondents from a nine institutions stated it is planned to be implemented. Few respondents stated they had formal MSK-DUSI qualifications (4/59), however 7 respondents stated they were in the process of becoming certified. Most respondents expressed an interest in the prospect of incorporating MSK-DUSI at their chiropractic program. 65% stated that chiropractic programs should provide MSK-DUSI training to chiropractic students and 75% of respondents stated that chiropractic programs should be providing accredited post-graduate MSK-DUSI courses.

Conclusion: The current utilization of MSK-DUSI among chiropractic programs is low but the general opinions of diagnostic imaging staff indicate a positive attitude to its use and possible growth in its utilization if foundational work including gaining funding, accreditation, and acceptance of musculoskeletal ultrasound (MSK-US) within the scope of chiropractic practice is undertaken.

## Introduction

Musculoskeletal ultrasound (MSK-US) is an imaging modality that provides accurate, safe and real-time diagnostic applications.<sup>1-4</sup> MSK-US is employed for diagnostic purposes and to monitor progress during rehabilitation programs.<sup>5-9</sup> These different utilizations are referred to as musculoskeletal diagnostic ultrasound imaging (MSK-DUSI) and rehabilitative ultrasound imaging (RUSI).<sup>10</sup> In the last two decades, interest in MSK-DUSI has increased outside the specialist radiology field, including among chiropractors.<sup>3,</sup>

<sup>11</sup> This article reports on the current utilization of MSK-DUSI at chiropractic programs worldwide and the opinions of academic diagnostic imaging staff of its prospective use at their teaching institution.

Diagnostic ultrasound has been utilized in medicine since the early 1950s.<sup>5, 9</sup> The application of diagnostic ultrasound developed rapidly over the following decades to become well-established in clinical obstetrics, gynaecology, cardiology and sports medicine.<sup>5</sup> Diagnostic ultrasound is currently viewed by many of these clinical disciplines, when used appropriately, as an extension of the physical examination.<sup>12</sup> In the 1980's,

there was a brief period of interest in MSK-DUSI amongst chiropractors, when it was hoped that adult spinal canal structures could be imaged, but it was soon discovered that the technology to adequately visualise those structures had not yet been developed.<sup>13-29</sup> Although the current state of MSK-DUSI technology has improved and can be used in limited circumstances around the spine, technical limitations persist, and MSK-DUSI is still more commonly used to evaluate superficial pathology of the extremities.

Recent advances in MSK-DUSI technology have allowed for good quality ultrasound images to be obtained from affordable equipment about the size of a notebook computer.<sup>30-34</sup> In fact, resolutions have been compared that of magnetic resonance imaging (MRI)<sup>31</sup>, although the best images are still gained through larger, cart-based systems.<sup>30-32</sup> MSK-DUSI also allows for the capacity to use power Doppler imaging which is sensitive in detecting areas of hyperaemia.<sup>30</sup> This is of interest in the assessment and diagnosis of overuse injuries, rheumatologic conditions and tumors.<sup>35</sup> These advances in technology and affordability have resulted in a resurgence in the interest in MSK-DUSI among non-radiologists.<sup>11</sup>

A review of the literature found few studies exploring MSK-DUSI within chiropractic programs. A pilot study by Hung et al. (2012) demonstrated that it is possible to teach relative novices (senior chiropractic students) normal sonographic anatomy.<sup>36</sup> Previous studies from other professions also found that novice interpreters can be trained in a limited field to the standard of an experienced interpreter.<sup>37-40</sup> As MSK-DUSI becomes more affordable and accessible to chiropractors, increased utilization and a growing body of literature may emerge. This is evident in that the number of MSK-DUSI training courses tailored for chiropractors has been increasing, as have papers published on the subject.<sup>14, 17, 36, 41-50</sup>

MSK-DUSI has been reported as a valid musculoskeletal imaging technique of the extremities<sup>3, 10</sup> and has multiple advantages as a primary diagnostic modality. It is portable, affordable and highly accessible. In addition it allows for dynamic, real-time imaging, with side-to-side comparisons. The main disadvantages are operator dependence and a steep learning curve. Nevertheless, a high percentage of chiropractic patients report with musculoskeletal complaints of the extremities.<sup>51, 52</sup> It seems appropriate that chiropractic programs could benefit from utilizing MSK-DUSI. Improving patient care is pivotal in all healthcare professions and by developing MSK-DUSI in chiropractic may allow for earlier, more accurate diagnosis

and potentially improved patient management and outcomes. These benefits make MSK-DUSI well suited to chiropractic patient care and research.

To date there have been no studies investigating the current and prospective utilization of MSK-DUSI at chiropractic teaching programs worldwide. The purpose of this paper was to investigate the current utilization of MSK-DUSI at chiropractic programs worldwide and to elicit opinions of academic diagnostic imaging staff of its prospective use at their teaching institution.

## Methods

### *Study design*

An internet-based, anonymous survey was designed using SurveyMonkey.<sup>53</sup>

The study group consisted of those individuals employed to teach diagnostic imaging at all 41 chiropractic teaching institutions worldwide ( $n = 127$ ). Ethics approval was obtained from Murdoch University Human Research (approval number 2014/110). An information letter was posted on the web page before the start of the questionnaire and **consent** was acknowledged if respondents continued through to the questionnaire.

A list of the diagnostic imaging staff email addresses was obtained online through publically available websites of teaching institutions or via a preliminary email to the Department Head of Radiology or Head of the Chiropractic School requesting contact details for the relevant staff members.

A modified Dillman method was used for survey administration.<sup>54</sup> In mid-2014, a preliminary notice was disseminated one week before the study to herald its arrival and to inform the recipients of the purpose of the study, stimulate their interest and ask for their cooperation. Following the preliminary notice an online survey link was sent directing the recipient to SurveyMonkey to answer and submit their responses to the

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questionnaire. Three reminders followed at fortnightly intervals. The entire data collection process took nine weeks.

### ***Questionnaire design and content***

The questionnaire ([figure 1 Appendix A](#)) consisted of multiple-choice and 7-point Likert-type items (with a few free-text answer boxes for some items included). The scale used for the 7-point Likert-type items were as follows. 1 = Strongly Agree; 2 = Moderately Agree; 3 = Slightly Agree; 4 = Don't Know; 5 = Slightly Disagree; 6 = Moderately Disagree; 7 = Strongly Disagree. The items were designed to elicit responses covering five sections. 1) Basic demographic data including: age, gender, occupational title, qualifications, experience and current chiropractic teaching institution of employment. 2) Current utilization of MSK-DUSI. 3) Training on the use MSK-DUSI. 4) Desire to utilize MSK-DUSI. 5) Perceived barriers to the utilization MSK-DUSI. A final open-ended item allowed respondents to record any other thoughts or opinions they may have on the topic.

There was no previous validated questionnaire upon which to base this survey instrument. Instead we used direct questions and Likert scales<sup>55</sup>. The questionnaire was designed by the lead author and then reviewed by the other authors as well as another colleague, a Diplomate of the American Chiropractic Board of Radiology (DACBR) for logic, consistency, and readability. However, it was not pre-tested or validated. The credentials of those who contributed to the development of the survey included: Doctor of Chiropractic (4); DACBR (2); Masters of Applied Science in Medical Imaging (1); Masters of Public Health (1); Doctor of Public Health (1).

### ***Sample size***

The aim was to recruit as many participants from as many chiropractic programs as possible. According to the World Federation of Chiropractic there are 41 chiropractic programs worldwide.<sup>56</sup> A Google search (April 2014) by the authors also confirmed these 41 chiropractic programs. The diagnostic imaging staff at each were contacted. No response was received from 7 institutions initially, so the websites of those

institutions were searched for relevant staff. The total number of individuals teaching diagnostic imaging was 127 (July 2014). Due to the small number of potential respondents, a response rate of about 50% was deemed adequate to be largely representative. This equated to 21 chiropractic programs and 64 staff members.

### ***Analysis***

The data were entered into a statistics program (SPSS version 21) and cleaned by looking for outliers and non-plausibilities. Descriptive statistics were used to describe basic demographic data and the results of the numerical scales used in each item.

### **Results**

#### ***Response***

Questionnaires were returned by 59 out of 127 respondents (response rate: 46.5%) from 24 out of 41 chiropractic programs (response rate: 58.5%). Some questionnaires were partially incomplete (n = 4), which accounts for the differing number of reported responses.

#### ***Demographic characteristics***

Table 1 displays the demographic details of participating diagnostic imaging staff at chiropractic teaching institutions worldwide. Respondents were typically male (35/54), with approximately one-third aged 51-60 years. Most respondents taught at institutions in North America, with an occupational title of Professor, and relevant qualifications to include both chiropractor and DACBR. The ‘other’ qualifications included four Master of Science degrees and one registered nurse.

#### ***Current utilization***

Table 2 displays the responses to items enquiring about current utilization of MSK-DUSI at chiropractic teaching institutions worldwide. Of the 24 chiropractic programs, 5 currently utilize MSK-DUSI at their teaching institution (North America = 3; Europe = 2); 9 stated that it is planned to be implemented (North

America = 8; Australia = 1); and 10 stated that there is no plan to implement MSK-DUSI (North America = 8; Australia = 2; Asia = 1).

Table 3 displays the responses of items relating to the 5 chiropractic programs that answered ‘yes’ to utilizing MSK-DUSI. Most chiropractic teaching institutions had employed MSK-DUSI for 1-2 years and use it routinely several times per week in a clinic or teaching setting. All 5 chiropractic programs utilize MSK-DUSI in teaching clinics and it was typically operated and interpreted by a chiropractic radiologist (DACBR). One chiropractic teaching institution stated “we run a post-graduate training centre in ultrasound studies for chiropractors, doctors, physiotherapists, osteopaths and sonographers”. Of these 5 chiropractic programs, 4 taught the interpretation and operation of MSK-DUSI to its chiropractic students and 3 taught the interpretation and operation of MSK-DUSI to their chiropractic radiology residents (candidates for the DACBR). Table 4 and Table 5 demonstrate the level of competency of each.

#### ***Formal MSK DUSI qualifications and experience***

There were 26 responses to the item enquiring about formal MSK-DUSI qualifications held by the diagnostic imaging staff. Of these, 14 responses were staff from one of the 5 teaching institutions that currently utilize MSK-DUSI. All 14 respondents were chiropractors and 10 also held current DACBR status. The formal MSK-DUSI qualifications held by the respondents included: formal training during chiropractic radiology residency and continued training as DACBR (7); American Institute of Ultrasound in Medicine (AIUM) accredited (1); and Master of Science (MSK-US) (1). The other 5 respondents were in the process of completing formal MSK-DUSI qualifications, including: Registered in Musculoskeletal™ (RMSK™) sonography credential (4) and a Master of Science (MSK-US) (1). The remaining 12 responses were from staff not employed at an institution that currently utilizes MSK-DUSI. Only 2 respondents held a formal MSK-DUSI qualification: musculoskeletal sonographer. Two respondents were in the process of completing formal MSK-DUSI qualifications, including: Registered in Musculoskeletal™ (RMSK™) sonography credential (1) and a Master of Science (MSK-US) (1). The remaining 8 respondents had received no formal qualifications or formal training, and stated that they had less than 1 year of experience in MSK-DUSI operation and interpretation.

Table 6 shows the years of experience in operating and interpreting MSK-DUSI held by diagnostic imaging staff at chiropractic teaching institutions (n = 26, follow up item to formal MSK-DUSI qualifications). Most respondents had 1-5 years' experience in the operation and interpretation of MSK-DUSI.

#### ***Barriers to utilization***

The barriers to the utilization (Table 7) were predominately the initial cost of purchasing the equipment, cost of training, time availability for staff to undertake training and limited access to training were the most consistent barriers reported by the respondents. 9 respondents used the 'other' section, in which several common ideas were found. They included the perception that MSK-US was not within a chiropractor's scope of practice; an already overloaded curriculum; and government controls/regulations.

#### ***Desire to utilize MSK-DUSI***

Table 8 displays the responses to items relating to potential future utilization and scope of practice. A majority (76.4%) of respondents stated that MSK-DUSI is within a chiropractors' scope of practice and 89% stated that it is an important imaging modality in the future of the chiropractic profession. Over two-thirds (65.4%) stated that chiropractic programs should provide MSK-DUSI training to chiropractic students, with three-quarters stating that chiropractic programs should be providing accredited post-graduate MSK-DUSI courses (74.6%). Most (76.4%) also stated that MSK-DUSI training should be made more accessible to chiropractors. The prospective uses of MSK-DUSI in teaching institutions included the following: research, 90.9%; diagnosis (teaching clinic), 90.9%; tracking treatment response (teaching clinic), 80.1%; rehabilitation/biofeedback (teaching clinic), 65.5%; and patient education (teaching clinic), 50.9%. Most (85.5%) also stated that chiropractic radiologists and residents should be proficient in MSK-DUSI.

#### **“Additional Comments”**

Responses from the “additional comments” section of the survey can be viewed in [figure 2Appendix B](#).

## Discussion

This survey explored the current utilization of MSK-DUSI at chiropractic programs worldwide and elicited opinions of academic diagnostic imaging staff of its prospective use at their teaching institution. To the authors' knowledge, this is the first survey of its type. The results highlight a number of points that improve understanding of the perception of the utility of the modality for the profession. Current utilization among the schools is low (5/24). However, respondents from 9 schools reported plans to implement MSK-DUSI in their programs. Most respondents expressed an interest in the prospect of incorporating MSK-DUSI at their teaching institution, even if plans were not imminent. This finding was consistent with results of studies involving sports medicine physicians, rheumatologists and physiotherapists.<sup>57-60</sup> No studies investigating the current utilization of MSK-DUSI among other health professions schools were found, and future research in this area is recommended.

The results show that potentially more than half of North American chiropractic schools will be utilizing MSK-DUSI in the future (11/19). This suggests that North American policy makers and imaging experts in chiropractic education may wish to consider developing relevant and standardised MSK-DUSI regulations. The regulations should meet the accredited standards as outlined by the appropriate regulatory body (e.g. for the United States of America – the American Institute of Ultrasound in Medicine<sup>61</sup>). Only 1 of 3 accredited Australian University chiropractic courses stated that it is planning to implement MSK-DUSI. However, this curricular shift indicates that policy makers should consider developing relevant training programs that meet the standards of the regulating body, the Australian School of Ultrasound in Medicine<sup>62</sup>.

This leads to the question of whether training should be provided at an under-graduate or post-graduate level or both. Most respondents expressed a greater favour towards providing post-graduate training rather than under-graduate training. Proficient in MSK-DUSI requires a thorough knowledge of sectional anatomy, ultrasound physics and technology, joint ultrasound scanning methods, the sonographic pattern of normal and pathological musculoskeletal tissues, artefacts, diagnostic criteria and Doppler technique.<sup>63</sup> Minimum training requirements for MSK-DUSI have been proposed by professional bodies in Australia, America and Europe for non-radiologists, and they are extensive.<sup>61, 62, 64</sup> The requirements described are not possible to

teach at an undergraduate level without sacrificing another component of the curriculum. At an undergraduate level it may be feasible to teach an introduction to MSK-DUSI and one anatomical region of normal sonographic anatomy as shown by Hung et al. (2012)<sup>36</sup> or to provide MSK-DUSI as an elective for those students with a keen interest. The potential for MSK-DUSI training at a post-graduate level seems more feasible.

The respondents viewed the initial cost of purchasing the equipment, closely followed by time availability of staff to undertake training as the principal barriers to the utilization of MSK-DUSI in teaching institutions. Respondents stated operator and reader variability as the fifth most significant barrier, which is usually reported higher in the literature.<sup>31, 65, 66</sup> This finding may be explained by the fact chiropractic schools have much smaller budgets than medical, physiotherapy and podiatry programs, therefore the cost may be more significant to a chiropractic school. Another possible explanation may be the fact that many respondents were speculating, having had no actual experience using the modality. Operator and reader variability may only be fully understood as a barrier after training. No studies investigating the barriers to the utilization of MSK-DUSI in other healthcare teaching institutions were found. However, barriers to the utilization of MSK-DUSI in clinical practice from other healthcare settings, including rheumatology, sport medicine and physiotherapy have been reported.<sup>57-59, 67, 68</sup> These barriers are comparable to those in this study: cost, time, accessibility to training, operator and reader variability and impact on patient care. There is no simple answer to overcoming these barriers. The implementation of MSK-DUSI within chiropractic programs would require time and commitment from policy makers and academic staff to ensure successful execution. If training programs are implemented in the future, students and practitioners willing to undertake the necessary commitment to develop adequate skills in MSK-DUSI should be able to use this skill in clinical practice with the suitable remuneration. As such, courses should be accredited or at a minimum provide advanced standing for becoming certified by the appropriate regulatory body. Investigating the eligibility for national healthcare rebates, private health and other third party rebates for chiropractors who are certified and perform MSK-DUSI should be considered a high priority.

In addition to teaching diagnostic ultrasonography, nearly all respondents stated MSK-DUSI should be used as a diagnostic tool in teaching clinics and research. Respondents reported over 14 individual studies suggesting a growing body of literature within the profession is likely to emerge. A brief description of each study is provided in Table 9. MSK-US has also been proposed as an adjunct resource to teaching anatomy.<sup>69-</sup>

<sup>71</sup> MSK-US can provide students an understanding of the dynamic living anatomy of the musculoskeletal system. Two pilot studies in medical education have shown that MSK-US enhances knowledge and understanding of the musculoskeletal system when used in conjunction with standard anatomy resources (e.g. cadavers, models, plain films etc.).<sup>70, 71</sup> Further studies are required to understand the best context for MSK-US as an anatomy teaching resource.

#### Strengths of this study

To the authors knowledge this is the first study to investigate the current and prospective use of MSK-DUSI among chiropractic schools worldwide. The number of returned questionnaires (n = 59/127) represented chiropractic diagnostic imaging staff from over 50% of the tertiary institutions (n = 24/41). Given the response rate, the author's feel that the results offer reasonable external validity regarding the opinion of diagnostic imaging staff at chiropractic teaching institutions worldwide, however it is possible that non-responders hold a different view. The target population was seen as a strength, as the diagnostic imaging experts at teaching institutions were likely to be aware of the existence of the emerging technology, familiar with at least some literature on the subject, and have some level of interest.

#### Limitations

This study has a weakness because the population sampled has an interest in this technology, which may have led to overly optimistic responses regarding the likelihood of adopting ultrasound at their institutions.

A limitation in sampling a population of chiropractors is the influence of the historical use of diagnostic imaging in the profession, that is, for chiropractic subluxation analysis. Respondents may have devalued ultrasound since it has not been found useful for that purpose. This historical chiropractic ideology may also have led to some of the non-responses to the survey. Finally, the survey instrument was used *de novo* and

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**Commented [cj3]:** ??? How is this a limitation of the study? This is not clear. Please clarify. Thanks!

**Commented [cj4]:** You may be too focused on the vitalists. Consider broadening your limitations so that they include anyone else who may not have responded. At this time, you are only guessing, unless you have data to show that the vitalists are the non-responders?

**Commented [KJY5]:** I thought this was explained by the previous sentence, but I guess you could drop this sentence. I recommend keeping the previous sentence, but maybe put it at the end. As for other limitations, I guess insert the response rate, maybe language barrier which might have prevented some from responding, like Mexico, Spain, etc. and any others mentioned in the 18:05 comment.

was not pre-tested however most items were direct questions and no combined summative scores were used from them. ~~Nevertheless, further testing of the survey instrument should be undertaken.~~ MORE LIMITATIONS GO HERE...

## Conclusion

Given the high level of interest in MSK-DUSI indicated by respondents at several institutions, it seems possible that some chiropractic programs may be at the forefront in providing relevant MSK-DUSI training in the future. However, the barriers to implementation are ~~not insignificant~~, and strategies to overcome them would need to be developed, including gaining funding, accreditation, and acceptance of ultrasound within the scope of chiropractic practice. In preparation for the future, policy makers and imaging experts in chiropractic education may wish to consider developing these foundational items. Future research in this area will need to evaluate the role of simulation in education, assessment, and competency measure for MSK-US; investigate if students have an interest in operating and interpreting MSK-US; develop a consensus led diagnostic imaging curriculum for chiropractic training.

## Acknowledgements

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## FUNDING SOURCES AND CONFLICTS OF INTEREST

No funding sources or conflicts of interest were reported for this study.

**Commented [cj6]:** Conclusion - Please include a conclusion statement that addresses the purpose of the study. Please revise conclusion in abstract and at end of paper so it does not extrapolate beyond the study findings. Only include statements relevant to the conclusion in the conclusion section. "The conclusion of a paper ... should provide insightful statements about the importance and relevance of the study without generalizing beyond the study's findings. It is not meant to replicate the abstract or other areas already mentioned in the paper. The conclusion should not interject author opinions, make unsupported claims, or give statements that go beyond the limits of the study findings. This section should be brief, perhaps 1 or 2 paragraphs, and provide clear answers and summarize how the research thesis or hypothesis presented in the introduction was addressed."

**Commented [KJY7]:** I have to admit that I'm not sure how to answer her queries. Maybe it just that 1. Few chiro schools use dusi 2. More want to take it up 3. Stuff like that, just brief summary of findings.

**Commented [cj8]:** Reword double negative

**Commented [cj9]:** This seems to be more discussion than conclusion? Consider moving to discussion section.

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### Table legend

Table 1 Demographic characteristics of participating diagnostic imaging staff at chiropractic teaching institutions worldwide.

Table 2 Current utilization of MSK-DUSI at chiropractic teaching institutions.

Table 3 Time, utilization and purpose of MSK-DUSI employed at chiropractic teaching institutions.

Table 4 Level of competency taught to chiropractic students (n = 4).

Table 5 Level of competency taught to chiropractic radiology residents (n = 3).

Table 6 Years of experience in operating and interpreting MSK-DUSI held by diagnostic imaging staff who responded to formal qualifications.

Table 7 Barriers to the utilization of MSK-DUSI in chiropractic teaching institutions.

Table 8 The opinion of diagnostic imaging staff at chiropractic teaching institutions desire to employ MSK-DUSI within chiropractic programs and its scope of practice within the profession.

Table 9 Active research studies at chiropractic programs (mid-2014).

### ~~Figure legend~~Appendices

~~Figure Appendix A~~4 Electronic Survey Instrument sent to Chiropractic Teaching Institutions.

~~Figure 2~~Appendix B Responses from the “Additional Comments” section of the survey (unedited).

**Table 1** Demographic characteristics of participating diagnostic imaging staff at chiropractic teaching institutions worldwide.

|                                                | Mean                |
|------------------------------------------------|---------------------|
| <b>Gender</b>                                  | <b>No. (n = 54)</b> |
| Females                                        | 19                  |
| Males                                          | 35                  |
| <b>Age</b>                                     | <b>No. (n = 54)</b> |
| 21-30                                          | 10                  |
| 31-40                                          | 8                   |
| 41-50                                          | 14                  |
| 51-60                                          | 18                  |
| 61 and above                                   | 4                   |
| <b>Location/Region</b>                         | <b>No. (n = 54)</b> |
| North America                                  | 43                  |
| South America                                  | 0                   |
| Australia                                      | 5                   |
| Asia                                           | 3                   |
| Europe                                         | 3                   |
| South Africa                                   | 0                   |
| <b>Occupational Title</b>                      | <b>No. (n = 54)</b> |
| Professor                                      | 20                  |
| Assistant/Associate Professor                  | 14                  |
| Diagnostic Imaging/Radiology Resident          | 8                   |
| Senior Lecturer                                | 5                   |
| Chiropractic Radiologist                       | 3                   |
| Chiropractor                                   | 3                   |
| Radiographer                                   | 1                   |
| <b>Relevant Qualifications</b>                 | <b>No. (n = 54)</b> |
| Chiropractor, DACBR                            | 30                  |
| Chiropractor                                   | 10                  |
| Chiropractor, DACBR, other                     | 3                   |
| Chiropractor, other                            | 2                   |
| Chiropractor, Radiographer                     | 2                   |
| Radiographer                                   | 2                   |
| Chiropractor, PhD                              | 1                   |
| Chiropractor, DACBR, PhD                       | 1                   |
| Chiropractor, DACBR, Sonographer, Radiographer | 1                   |
| Sonographer                                    | 1                   |
| Chiropractor, DACBR, Radiographer, Sonographer | 1                   |
| <b>Years since registered as chiropractor</b>  | <b>No. (n = 54)</b> |
| 0-10                                           | 19                  |
| 11-20                                          | 11                  |
| >21                                            | 21                  |
| Not Applicable                                 | 3                   |
| <b>Years since registered as DACBR</b>         | <b>No. (n = 54)</b> |
| 0-10                                           | 13                  |
| 11-20                                          | 12                  |
| >21                                            | 11                  |
| Not Applicable                                 | 18                  |

**Table 2** Current utilization of MSK-DUSI at chiropractic teaching institutions.

|                                         | Mean                |
|-----------------------------------------|---------------------|
| <b>Current Utilization</b>              | <b>No. (n = 24)</b> |
| Yes                                     | 5                   |
| No, but it is planned to be implemented | 9                   |
| No, and there is no plan to implement   | 10                  |

**Table 3** Time, utilization and purpose of MSK-DUSI employed at chiropractic teaching institutions.

|                                  | Mean               |
|----------------------------------|--------------------|
| <b>Time</b>                      | <b>No. (n = 5)</b> |
| <6 months                        | 1                  |
| 6 months – 1 year                | 0                  |
| >1-2 years                       | 4                  |
| >2-5 years                       | 0                  |
| >5-10 years                      | 1                  |
| >10 years                        | 0                  |
| <b>Times per week</b>            | <b>No. (n = 5)</b> |
| Once per a week                  | 0                  |
| Several times per week           | 3                  |
| Everyday                         | 1                  |
| Multiple times a day             | 1                  |
| <b>Who utilizes (n = 5)</b>      |                    |
| Chiropractic students            | 2                  |
| Chiropractic radiology residents | 2                  |
| Chiropractic radiologists        | 4                  |
| Non-radiologist chiropractors    | 3                  |
| Medical radiologists             | 3                  |
| Radiographers/Sonographers       | 2                  |
| Other                            | 1                  |
| <b>Purpose (n = 5)</b>           |                    |
| Diagnosis                        | 5                  |
| Tracking response to treatment   | 4                  |
| Patient education                | 4                  |
| Rehab/biofeedback                | 2                  |
| Teaching                         | 4                  |
| Research                         | 4                  |
| Other                            | 0                  |

**Table 4** Level of competency taught to chiropractic students (n = 4).

| Very Basic:<br>'can identify<br>basic<br>anatomy in<br>one body<br>area but<br>cannot<br>identify<br>pathology' | very<br>basic | basic | somewhat<br>competent | competent | very<br>competent | Very<br>Competent:<br>'able to<br>diagnose all<br>applicable<br>conditions in<br>all body areas' |
|-----------------------------------------------------------------------------------------------------------------|---------------|-------|-----------------------|-----------|-------------------|--------------------------------------------------------------------------------------------------|
|                                                                                                                 | 2             | 1     | 1                     | -         | -                 |                                                                                                  |

**Table 5** Level of competency taught to chiropractic radiology residents (n = 3).

| Very Basic:<br>'can identify<br>basic<br>anatomy in<br>one body<br>area but<br>cannot<br>identify<br>pathology' | very<br>basic | basic | somewhat<br>competent | competent | very<br>competent | Very<br>Competent:<br>'able to<br>diagnose all<br>applicable<br>conditions in<br>all body areas' |
|-----------------------------------------------------------------------------------------------------------------|---------------|-------|-----------------------|-----------|-------------------|--------------------------------------------------------------------------------------------------|
|                                                                                                                 | -             | 1     | -                     | -         | 2                 |                                                                                                  |

**Table 6** Years of experience in operating and interpreting MSK-DUSI held by diagnostic imaging staff who responded to formal qualifications.

|                            | Mean                |
|----------------------------|---------------------|
| <b>Years of experience</b> | <b>No. (n = 26)</b> |
| <1                         | 9                   |
| 1-5                        | 10                  |
| 6-10                       | 5                   |
| 11-20                      | 2                   |

**Table 7** Barriers to the utilization of MSK-DUSI in chiropractic teaching institutions.

|                                                  | Mean |
|--------------------------------------------------|------|
| <b>Barriers (n = 55)</b>                         |      |
| Cost of purchasing the equipment                 | 42   |
| Time availability of staff to undertake training | 37   |
| Limited accessibility to training                | 33   |
| Cost of training                                 | 31   |
| Operator and reader variability                  | 23   |
| Other                                            | 9    |
| Doubt of its utility and impact on patient care  | 5    |
| None                                             | 2    |
| Doubt of its utility and impact on research      | 1    |

| <b>Table 8</b> The opinion of diagnostic imaging staff at chiropractic teaching institutions desire to employ MSK-DUSI within chiropractic programs and its scope of practice within the profession. |                  |                       |                     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----------------------|---------------------|
|                                                                                                                                                                                                      | <b>Agree (%)</b> | <b>Don't know (%)</b> | <b>Disagree (%)</b> |
| MSK-DUSI is within a chiropractors' scope of practice. (n=55)                                                                                                                                        | 76.4             | 1.8                   | 21.9                |
| MSK-DUSI is an important imaging modality in the future of the chiropractic profession. (n=55)                                                                                                       | 89.0             | 5.5                   | 5.4                 |
| Chiropractic Radiologists and Residents should be proficient in MSK-DUSI. (n=55)                                                                                                                     | 85.5             | 3.6                   | 10.9                |
| MSK-DUSI training should be made more accessible to chiropractors. (n=55)                                                                                                                            | 76.4             | 5.5                   | 18.3                |
| <b>MSK-DUSI should be implemented in to chiropractic teaching institutes for the purpose of:</b>                                                                                                     |                  |                       |                     |
| Providing MSK-DUSI training to chiropractic students. (n=55)                                                                                                                                         | 65.4             | 3.6                   | 30.9                |
| Providing accredited post-graduate MSK-DUSI courses. (n=55)                                                                                                                                          | 74.6             | 5.1                   | 13.6                |
| Research. (n=55)                                                                                                                                                                                     | 90.9             | 3.6                   | 5.4                 |
| Diagnosis (teaching clinic). (n=55)                                                                                                                                                                  | 90.9             | 1.8                   | 7.2                 |
| Tracking treatment response (teaching clinic). (n=55)                                                                                                                                                | 80.1             | 10.9                  | 9.1                 |
| Patient education (teaching clinic). (n=55)                                                                                                                                                          | 50.9             | 20.0                  | 29.1                |
| Rehabilitation/biofeedback/RUSI (teaching clinic). (n=55)                                                                                                                                            | 65.5             | 21.8                  | 12.7                |

**Table 9** Active research studies at chiropractic programs (mid-2014)

| Number | Study/Brief description                                                                                                                                  | Tertiary Institution                   |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| 1.     | The evaluation of cervical and lumbar erector spinae (multifidus) activation with MSK-DUSI.                                                              | Anglo-European College of Chiropractic |
| 2.     | Project utilizing diagnostic ultrasound to investigate the accuracy of acupuncture/dry needling placement.                                               |                                        |
| 3.     | Sonoelastography assessment of various muscles and tendons.                                                                                              |                                        |
| 4.     | The reliability of sonoelastography in assessing patella tendon softening.                                                                               |                                        |
| 5.     | The evaluation of the lower lumbar facet joints to determine mobility of facet joints pre and post manipulation with diagnostic ultrasound.              | National University of Health Sciences |
| 6.     | The evaluation of the lower lumbar facet joints to determine CSF flow pre and post manipulation with diagnostic ultrasound.                              |                                        |
| 7.     | The ultrasound assessment of compression of the brachial plexus in various arm positions in patients with clinically suspected thoracic outlet syndrome. | Logan University                       |
| 8.     | The ultrasound assessment of sciatic nerve compression at the piriformis muscle.                                                                         |                                        |
| 9.     | MSK-DUSI in the assessment of adhesive capsulitis.                                                                                                       |                                        |
| 10.    | MSK-DUSI in the assessment of sub-gluteal etiology of sciatica.                                                                                          |                                        |
| 11.    | MSK-DUSI in the assessment of the inter-scalene interval.                                                                                                | University of Western States           |
| 12.    | Diagnostic ultrasound in the assessment of vascular risk factors (cervical).                                                                             |                                        |
| 13.    | Various projects acquiring sonographic measurements of various structures (nerves, tendons, anatomic spaces) for normative data.                         |                                        |
| 14.    | The level of knowledge by doctors of chiropractic for the clinical application MSK-DUSI: survey.                                                         |                                        |

## Current Utilization

### 1. Does your teaching institution currently utilize MSK-DUSI?

("yes, continue to question 2," "no, but it is planned to be implemented, proceed to question 9" or "no, and there is no plan to implement, proceed to question 9")

### 2. How long has your teaching institution employed MSK-DUSI?

("<6 months," "6 months – 1 year," ">1-2 years," ">2-5 years," ">5-10 years," or ">10 years")

### 3. Does your teaching institution use it on a routine basis?

("once per a week" "several times per week," "every day," or "multiple times a day")

### 4. Who currently utilizes MSK-DUSI at your teaching institution? (mark all that apply)

("chiropractic students," "chiropractic radiology residents," "chiropractic radiologists," "non-radiologist chiropractors," "medical radiologists," "radiographers," or "other – please state")

### 5. For what purpose does your teaching institution utilize MSK-DUSI? (mark all that apply)

("diagnosis in chiropractic teaching clinic," "tracking response to treatment in chiropractic teaching clinic," "patient education in chiropractic teaching clinic," "rehabilitation/biofeedback," "teaching" "research," or "other – please state")

### 6. Does your teaching institution provide MSK-DUSI training to its chiropractic students?

("yes," or "no, proceed to question 8")

### 7. Please identify the level of training provided to your chiropractic students.

(E.g. Very Basic: 'can identify basic anatomy in one body area but cannot identify pathology'; Very Competent: 'able to diagnose all applicable conditions in all body areas')

(Very Basic –1—2—3—4—5—Very Competent)

### 8. Does your teaching institution provide MSK-DUSI training to its chiropractic radiology residents?

("yes," "no, proceed to question 10," or "not applicable, proceed to question 10")

### 9. Please identify the level of training provided to your chiropractic radiology residents.

(E.g. Very Basic: 'can identify basic anatomy in one body area but cannot identify pathology'; Very Competent: 'able to diagnose all applicable conditions in all body areas')

(Very Basic –1—2—3—4—5—Very Competent)

### 10. What MSK-DUSI research project(s) are currently active or in the process of being published at your teaching institution? (Please provide a title and brief purpose of the project; write N/A if not applicable)

### 11. What are the barriers to the utilization of MSK-DUSI in chiropractic teaching institutions? (mark all that apply)

("operator and reader variability," "cost of purchasing the equipment," "limited accessibility to training," "doubt of its utility and impact on patient care," "doubt of its utility and impact on research," "cost of training," "time availability of staff to undertake training," "none of the above" or "other – please state")

### 12. Using your answer(s) from the previous question, please state which barrier you believe is the greatest. (Please state 'none' if you selected 'none of the above')

### Desire to utilize MSK-DUSI

Please indicate your level of agreement with each of the following statements.

### 13. MSK-DUSI is within a chiropractors' scope of practice.

(Strongly Agree –1—2—3—4—5—6—7—Strongly Disagree)

### 14. MSK-DUSI is an important imaging modality in the future of the chiropractic profession.

(Strongly Agree –1—2—3—4—5—6—7—Strongly Disagree)

### 15. MSK-DUSI should be implemented in to chiropractic teaching institutes for the purpose of:

#### a) Providing MSK-DUSI training to chiropractic students.

(Strongly Agree –1—2—3—4—5—6—7—Strongly Disagree)

#### b) Providing accredited post-graduate MSK-DUSI courses.

(Strongly Agree –1—2—3—4—5—6—7—Strongly Disagree)

#### c) Research.

(Strongly Agree –1—2—3—4—5—6—7—Strongly Disagree)

**d) Diagnosis (teaching clinic).**  
(Strongly Agree –1—2—3—4—5—6—7—Strongly Disagree)

**e) Tracking treatment response (teaching clinic).**  
(Strongly Agree –1—2—3—4—5—6—7—Strongly Disagree)

**f) Patient education (teaching clinic).**  
(Strongly Agree –1—2—3—4—5—6—7—Strongly Disagree)

**g) Rehabilitation/biofeedback (teaching clinic).**  
(Strongly Agree –1—2—3—4—5—6—7—Strongly Disagree)

**16. Chiropractic Radiologists and Residents should be proficient in MSK-DUSI.**  
(Strongly Agree –1—2—3—4—5—6—7—Strongly Disagree)

**17. MSK-DUSI training should be made more accessible to chiropractors.**  
(Strongly Agree –1—2—3—4—5—6—7—Strongly Disagree)

**Basic Demographics**

**18. What is your age?**  
("21-30," "31-40," "41-50," "51-60," or "61 and above")

**19. Gender**  
(male/female)

**20. Occupational title (e.g. Professor, Clinician, etc.)**

**21. What are your relevant qualifications? (mark all that apply)**  
("chiropractor," "PhD," "DACBR," "M.D.," "radiographer," "sonographer," or "other - please state")

**22. How many years have you been a registered/licensed chiropractor?**  
("0-10," "11-20," ">21," or "not applicable")

**23. How many years have you been a chiropractic radiologist?**  
("0-10," "11-20," ">21," or "not applicable")

**24. What chiropractic teaching institute(s) do you currently work for? (Please state)**

**25. How many years of experience do you have in using MSK-DUSI?**  
("0," "<1," "1-5," "6-10," "11-20," "21-30," or ">30,")

**26. Please state what specific qualifications/certifications you have in using MSK-DUSI? (Please state no formal training if this applies)**

**27. Please provide any comments you would like to the investigators about the utilization of MSK-DUSI at chiropractic teaching institutes or among the profession.**

Appendix B Responses from the "Additional Comments" section of the survey (unedited).

- 1) 5 - 20 years ago DUSI was all the buzz with a lot of fluff regarding claims of the procedures diagnostic capabilities. These all did not pan out.
- 2) Only the most rigorous training should under taken, or we will see DUSI go the way of thermography and video fluoroscopy, both good tools for a select few patients. Those tools were turned into a screening tool and a generator of revenue rather than a diagnostic tool used in the best interests of the patient.
- 3) This survey does not ask questions that I believe are relevant to the emergent field of diagnostic ultrasound for MSK applications. My understanding of this modality is such that it requires focused training

that is equivalent to the fellowship training program for DU at Logan. I do believe that DACBRS and residents need to lead the charge in bringing this modality and understanding of its application to the chiropractic profession. I do not think that DACBRs and residents are all able to access this training to the point of allowing proficiency for use and for teaching. I wish we were. The larger population of chiropractors and students would then be better able to be instructed on such simple things as applications of the modality and its fundamental concepts. The literature shows that DU will be used more and more in the future for MSK and chiropractic concerns, but I do not think that the general population of DCs and DC students will be safely able to read these studies as primary interpreters in the foreseeable future.

4) DUSI is a great tool when diagnosing superficial pathology in the extremities. It does not have much, if any, use in the spine with the technology currently available. (Other than pure landmarks for injection purposes by medical professionals). The greatest limitation I see is that it is a very difficult technique to become proficient in and proper training is vital. If the operator is not trained well then I see it being a very dangerous imaging tool as people may claim they are visualizing something when they do not know what they are looking at. I see a great future of ultrasound in Chiropractic when the operator knows what they are doing. This is not an imaging modality that can be taught in a weekend course and understood at a higher level. It takes a long time to figure out and can be very helpful in clinical practice if done correctly.

5) As previously indicated DUSI has great potential within chiropractic. Patient education happens at the time of imaging. Has high satisfaction rating and better more realistic understanding of the problem if handled well. But beware! UG experience is valuable but acquisition of useful skill for PG is incomplete. Chiropractic programmes are academically packed. What will be taken out so that meaningful skill training can be inserted? There are organisations that give minimum standards and the level of appropriate training; and there is good literature support for post-professional requirements (rheumatology for example). I have been convinced that DUSI and chiropractic have a natural affinity for more than 20 yrs. Recently, the time has come. UG experience should be encouraged to demonstrate DUSI usefulness, clinically and educationally and encouragement to undertake an approved training programme at an appropriate PG stage. Chiropractic institutions are well positioned to offer DUSI training programmes (I am involved with two at different sites). However there needs to be an appropriate infrastructure in place, including clinical US trainers and placement facilities. Your Q are well structured and cover the main issues in DUSI applications. However it perhaps necessarily has significant limitations which no doubt will discuss in your dissertation. Good Luck with the work.

6) I think that DUSI is a modality that provides benefits to patient care. DACBRs should have access to training in this modality if they so choose. But given the limited use of the DUSI in chiropractic practices, I don't think it is a necessity in DACBR training. Teaching institutions are a natural fit for training DACBRs in DUSI and there is the added benefit of doing research for the institution. I don't think chiropractic students necessarily need to be taught how to read DUSI studies. I think that time would be better spent towards teaching them MRI/CT and more conventional modalities that they will likely encounter in practice. Thank you!

7) This modality will be as commonplace in the clinic as a stethoscope.

8) The AIUM recently came out with a position statement regarding the use of Diagnostic Ultrasound and what qualifications would be needed for a chiropractic physician to make diagnoses with it. I am strongly in favor of the requirement that the DC be a diplomate in either the ACBR or ACBSP fields.

9) Available educational courses for clinical chiropractic are limited if at all available. Use should be allowed only after intense training course.

10) chiropractors and radiologists who are not highly skilled in interpretation of DUSI should not be using it. it should not be a tool to dazzle patients standardization of regional exams should be a priority

11) Young chiropractors are graduating hoping to treat sports injuries. This is a great tool, as I said in an earlier comment, for use during clinical encounters. I hope that DACBRs don't attempt to constrain the use of MSUS. Good survey. Good luck!

12) Powerful dynamic examination tool when in the hands of a clinician trained in biomechanics, such as a chiropractor.

13) I believe that Msk DU is too operator dependent to allow DCs to perform and interpret. It should be done only by DACBRs with additional fellowship training.

14) I think that chiropractors should be aware of the types of pathology that can and can't be seen on US and should be able to make appropriate referrals and understand the implications of the reports

15) DUSI is an extremely important for use within chiropractic profession. However, it should not be used without proper training. Scanning skills, good equipment and good knowledge are important.

16) If the education is there, I am quite sure that the students will benefit from it. Also if there are courses for post-graduates as well, it will help a larger group of people both in the field and research.

17) In the seven plus years I have been performing, interpreting, and training ultrasound, it seems to me that the applications of diagnostic ultrasound may be limited for the general practice chiropractor. The sports chiropractor and the chiropractic radiologists seem to be the two groups that would utilize the imaging tool the most and in the most appropriate manner. Thanks!

18) As with other advanced imaging modalities, I think practicing clinicians should have an awareness of the clinical utility of MSK US, an understanding of when it should and shouldn't be used in the diagnosis and management of a patient case, and a working knowledge of MSK US and it's associated terminology in order to understand and implement the information from a radiology report generated by a radiologist. I do not think that training on the performance and interpretation of MSK US imaging should be a component of standard curriculum and training for chiropractic students. That information should appropriately be integrated into resident training for those seeking a radiology diplomate.

19) A few issues need to be addressed: The gross limitations of spinal ultrasound and the need for formal training prior to using US in clinical practice.

20) The importance of technique in the placement of the probe etc requires many hours of practice. There are already too many areas in which the student must be proficient, so I feel the DUS would detract from these other areas. Provided as an elective for students and as a post grad level course would make sense. The ability to correlate MRI is necessary since the DUS image is only so deep. I have seen significant overread of DUS in the shoulder when compared to high field strength MRI. In conclusion, the experience of the operator including the knowledge of anatomy, the knowledge of potential pathology and the technical act of DUS probe placement are the most significant things to keep everyone from performing DUS.

21) Ultrasound utilization should be limited to chiropractors with advanced training such as DACBR and DACBSP certifications. The RMSK certification should also be required.

22) Make sure that you hire a good person to teach you ultrasound since it is very technically demanding. Purchase videos from reliable sources to help you learn the basics in US. Practice makes perfect, so practice alot, otherwise you will lose your talent of performing studies.

23) I believe that it should be used in the profession and at teaching institutions by imaging specialists educated in the long term course training. This would cover both technical equipment usage as well as image interpretation.

24) I feel that DxUS is a fantastic modality for those interested; however, because of the challenging eye hand coordination I don't feel it would be a good fit for ALL chiropractic students (especially when I watch students fumble around with how to take a quality x-ray). I think that those interested should have more access to post-grad seminars in order to achieve training and competence with it.

25) Just one point of clarification. When talking about "using" DUSI, it was assumed you meant the application of the equipment and diagnosis, not just diagnosing DUS images acquired by someone else.