Anatomy knowledge retention in Australian osteopathic training: A comparative study

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SUMMARY

Anatomy knowledge retention is an important consideration in the training of health professionals. In this study, musculoskeletal anatomy knowledge retention was measured in students enrolled in the osteopathic programs at Southern Cross University, Australia. The double-degree osteopathic program has recently undergone curriculum change from five years to four years. Anatomy knowledge in the final-year students of the four-year program was compared to final-year students in the five-year program. Anatomy knowledge amongst the final-year students was also compared to osteopathic practitioners. To measure anatomy knowledge, a test consisting of 20 multiple-choice questions was used, with ten low-order and ten high-order questions, based on the Blooming Anatomy Tool. Students enrolled in the osteopathic program were invited to participate. A total of 92 students participated from a total of 106 students (student response rate of 86.8%). 118 osteopathic practitioners (osteopaths) completed the anatomy knowledge test from a possible 2,546 Australian osteopaths (response rate 4.6%). Retrospective data of anatomy knowledge retention amongst chiropractic students enrolled at Macquarie University, Australia was used to compare with the osteopathic students. There were no differences in the measured level of anatomy knowledge in both low-order and high-order questions between osteopathic students and osteopaths. There were no differences in the measured level of anatomy knowledge in both low-order and high-order questions between senior (fourth-year) students in the four-year program and senior (fifth-year) students in the five-year osteopathic program. The results from this study indicate there is a consistent level of anatomy knowledge retention among osteopathic students and practitioners.

Key words: Gross anatomy education – Knowledge retention – Osteopathic education – Medical education – Musculoskeletal anatomy – Anatomy curriculum

ABBREVIATIONS

Anatomy knowledge retention (AKR)

Australian Osteopathic Accreditation Council (AOAC)

Bachelor of Clinical Sciences (BClinSc)

Basic Competency Examination (BCE)

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Master of Osteopathic Medicine (MOM)

Musculoskeletal (MSK)

Progress Test in Medicine (PTM)

Southern Cross University (SCU)

Macquarie University (MU)

Low-Order (LO)

High-Order (HO)

INTRODUCTION

Anatomy has long been considered an essential foundation in the training of medical and health practitioners (Turney, 2007, Louw et al., 2009; Ahmed et al., 2010; Diaz-Mancha et al., 2016; Estai & Bunt, 2016; Dayal et al., 2017; Losco et al., 2017; Farey et al.,2018; Blaich et al., 2019). The study of anatomy aids in preparing students for clinical practice (Sugard et al., 2010; Valenza, 2012) not only through teaching about the structures of the human body, but also in the development of non-traditional discipline-independent skills (Rizzolo, 2010; Lachman and Pawlina, 2006; Strkalj, 2014; Evans et al., 2018; Hildebrandt, 2019). These skills include professionalism, time-management, empathy, teamwork, and respect for the patient (Swartz, 2006; Bockers et al., 2010; Talarico, 2010; White et al., 2011; Talarico, 2012).

In health profession programs, anatomy education is predominantly delivered in the first two years of training. In these early years, biomedical sciences dominate the curricula, giving way to more clinically oriented disciplines later in the program (Strkalj, et al., 2011; Nabil et al., 2014; McBride and Drake, 2018; Giuriato, et al., 2019; Arantes et al., 2020; Lufler et al., 2020). This type of delivery leads to a time interval between the initial acquisition of biomedical knowledge such as anatomy and the clinical application of that knowledge (Lufler et al., 2020). Anatomy knowledge retention (AKR) is therefore an important factor to consider when designing programs for health professional education.

AKR is a complex domain. Numerous studies have demonstrated anatomy knowledge attrition (i.e., a decrease in anatomy knowledge) in the latter stages of health profession programs (Feigin et al., 2002; Prince et al., 2005; Feigin et al., 2007; Lazarus et al., 2012; Jurjus et al., 2014; Brunk et al., 2017; Farey et al., 2018; Lufler et al., 2020). However, others have shown an increase in AKR as students' progress through their programs (Humphreys et al., 2007; Hulme et al., 2019).

With recent significant changes in the content and delivery of anatomy within medical and health professions education (McBride and Drake, 2016; Day et al., 2018; Lufler et al., 2020), concerns have been raised about the level of AKR of students as they graduate and move into clinical practice (McKeown et al., 2003; Prince et al., 2005; Humphreys et al., 2007; Ahmed et al., 2010; Bergmann et al., 2011; Strkalj et al., 2011; Jurjus et al., 2014; Meyer et al., 2015; Doomernik et al., 2017). These concerns extend to a broad range of health professions, including chiropractic (Stkalj et al., 2011), podiatry (Diaz-Mancha et al., 2016), optometry (Backhouse et al., 2019), and nursing (Narnaware and Neumeier, 2020).

In addition, other factors that can influence AKR such as vertical integration of anatomy knowledge within curricula (Bergman et al., 2011; Parmar and Rathinam, 2011; Bergman et al., 2014), composition of assessments (Blunt and Blizzard, 1975; Feigin et al., 2002; Feigin et al., 2007; Jurjus et al., 2016), anatomy curricula requiring specific clinical context (D'Eon et al., 2006; Kerfoot et al., 2007; Custers, 2010; Dobson and Linderholm, 2015; Karpicke and Blunt, 2011; Karpicke, 2012; Smith et al., 2016; Dobson et al., 2017; Dayal et al., 2017; Williams and Mann, 2017; Castillo et al., 2018; Farey et al., 2018) and their cumulative effect on AKR have not been fully explored.

Assessing the effect of these factors is important for designing strategies to improve AKR. Different assessment tools have been used to assess AKR. These include the Progress Test in Medicine (PTM) (Brunk et al., 2017), the Basic Competency Examination (BCE) (Freedman and Bernstein, 1998; Childs, et al., 2005; Stockard and Allen, 2006), the carpal and tarsal bone tests (Valenza et al., 2012; Diaz-Mancha et al., 2016), and Bloom's taxonomy-ordered multiple-choice questions (Hulme et al., 2019). While these studies produced valuable results in AKR assessment of different student cohorts, the use of different assessment tools hampered the comparison of AKR across disciplines and pedagogies. However, using the same AKR assessment tool on students from different discipline programs, and different educational institutions, demonstrated differences in levels of anatomy knowledge at similar stages of progression (Wass et al., 2001; Humphreys et al., 2007; Valenza et al., 2012; Brunk et al., 2016; Daiz-Mancha et al., 2016). This suggests that anatomy education within the health professions is a complex issue and that AKR may be dependent on both the anatomical region studied and the perceived importance of that anatomical region to the specific health discipline.

Studies focusing on AKR in medical (McKeown et al., 2003; Valenza et al., 2012; Nabil et al., 2014), physical therapy (Diaz-Muncha et al., 2016; Parmar and Rathinam, 2011; Valenza et al., 2012), podiatry (Castillo-Lopez et al., 2014), nursing (Zieber and Sedgewick, 2918; Narnaware and Neumeier, 2020), occupational therapy (Parmar and Rathinam, 2011), chiropractic (Strkalj et al., 2011), and osteopathic students (Stockard and Allen, 2006) did not compare levels of AKR with clinicians. Other studies focused on AKR in just clinicians such as medical practitioners (Spielmann and Oliver, 2005; Custers and Cute, 2011; Roche et al., 2011; Farey et al., 2018) and optometrists (Bakkum and Trachimowicz, 2015). These latter studies demonstrated that attrition of anatomy knowledge increased with time since graduation (Spielmann and Oliver, 2005; Custers and Cute, 2011; Bakkum and Trachimowicz, 2015). However, to date there has been only one investigation into AKR of musculoskeletal (MSK) anatomy in osteopathic students (Stockard and Allen, 2006), and no study of AKR in osteopathic practitioners within an Australian context.

This study had two aims. The first aim was to provide a preliminary assessment of musculoskeletal anatomy knowledge in the final-year osteopathic students at an Australian tertiary university, and thus their preparedness (in terms of anatomy knowledge) to enter the workforce. This was achieved through the comparison of the results of anatomy tests (focusing on the anatomy of limbs at two different cognitive levels) completed by the final-year osteopathic students and a sample of practicing osteopaths. In addition, test results of the final year students were compared with those of the final year chiropractic students from Macquarie University (MU). This comparison was considered valid because of the similarities between the two health professions, both focusing on musculoskeletal disorders and relying on manual therapy. The second aim was to assess anatomy knowledge of the final year students in two osteopathic programs, the old five-year program and the new four-year program.

MATERIALS AND METHODS

Student data was collected from students enrolled in the Master of Osteopathic Medicine (MOM) degree at Southern Cross University (SCU) in Lismore, New South Wales, Australia. Data were collected from osteopathic practitioners via an online discussion forum. The osteopathic program at SCU is a double-degree program consisting of an undergraduate Bachelor of Clinical Sciences (BClinSc) and a postgraduate MOM. Students must successfully complete both degrees to register as an osteopath in Australia. Both degrees are accredited with the Australian Osteopathic Accreditation Council (AOAC, 2020), the body responsible for osteopathic education accreditation in Australia.

The osteopathic program at SCU has recently undergone curriculum change through which duration to complete the double-degree program decreased from five to four years effectively reducing the MOM from two years to one year. The new, revised BClinSc degree remained three years in duration. The first student intake into the new four-year program commenced in February 2017. The main curriculum change in the new integrated program is that education is delivered and assessed within a clinically-oriented context with greater emphasis on evidence-based practice. The change included streamlining delivery to remove repetitious content, thereby improving the overall integration of the curriculum. This included the anatomical curriculum.

Anatomy curriculum at Southern Cross University

The anatomy curriculum in the revised program includes several anatomy units (subjects or courses) spread over two teaching sessions per year. The university has three 13-week teaching sessions per academic year). All units follow a common format and include face-to-face lectures (1 hour per week), tutorials (1 hour per week) and anatomy laboratory practical classes with prosected specimens (2 hours per week). The exception to this is the histology and embryology unit which does not have practical classes. Table 1 outlines the anatomy units in the old five-year and new four-year osteopathic programs at SCU.

Table 2 describes the content of each of the units listed in Table 1. In session 1 of year one in the new four-year program, there is a shared introductory unit covering the basic concepts of anatomy. Two osteopathic specific units (Osteopathic Science

Table 1. Anatomy curricula of the SCU osteopathic programs.

The 5-year osteopathic program (old program)				
	Teaching Session 1 Units		**Teaching Session 2 Units**	
Year	**Unit Code**	**Unit title**	**Unit Code**	**Unit title**
1	BIO01302	Human Anatomy *	BIO00209	Biomechanics & Kinesiology *
	BIO00207	Mechanics for Movement *	SCI10473	Histology & Embryology *
2	SCI10475	Neuroscience *		
	SCI10474	Advanced Visceral Anatomy		
The 4-year osteopathic program (new program)				
1	BIO01302	Human Anatomy *	OST71005	Osteopathic Science 1
2	OST71006	Osteopathic Science 2		
	SCI10475	Neuroscience *		

*= shared unit. i.e. common unit for several health science programs including Osteopathy.

Table 2. Anatomy syllabi of the SCU units.

The 5-year osteopathic program (Old program)		
	Unit title	**Unit description**
	Human Anatomy*	Introductory anatomy
	Mechanics for Movement	MSK gross anatomy
	Biomechanics & Kinesiology	MSK gross anatomy
	Histology & Embryology	Microscopic anatomy Developmental anatomy
	Neuroscience*	Neuroanatomy
	Advanced Visceral Anatomy	Visceral anatomy
The 4-year osteopathic program (New program)		
	Unit title	**Unit description**
	Human Anatomy*	Introductory anatomy
	Osteopathic Science 1	MSK gross anatomy Spinal gross anatomy
	Osteopathic Science 2	MSK gross anatomy Pectoral girdle Upper extremity Cranial anatomy Pelvic girdle Lower extremity
	Neuroscience*	Neuroanatomy

*: Units common to both the old five-year and new four-year programs.
MSK: musculoskeletal anatomy

1 and Osteopathic Science 2) are delivered in session 2 of year 1 and session 1 of year 2. These units include an in-depth study of the functional, clinical and biomechanical anatomy of each anatomical region. Osteopathic Science 1 covers the vertebral column (axial skeleton), and visceral anatomy while Osteopathic Science 2 covers the pectoral girdle and upper limb, pelvic girdle, lower limb, and the cranium. Student learning is supported by online resources delivered via the Blackboard learning management system (Blackboard Inc. Version 3.9.2). Students can access these online resources at any time and are used for both summative and formative assessment activities.

Participant Population

Participants in this study were the senior osteopathic students (both fifth-year students in the old five-year program and fourth-year students in the new four-year program) in the osteopathic programs at SCU and osteopathic practitioners working in private practice. Student data was collected from students enrolled in the MOM at SCU in Lismore, Australia. Eligible students were invited to participate during scheduled classes. Introducing the new four-year course while the old five-year course was being ‘taught out’ meant that there were two cohorts of students studying the same material at different stages of their respective courses. Table 3 details the different student cohorts and the stage of their respective programs.

Data were collected from osteopathic practitioners via two avenues: an online discussion forum, and direct paper-based. Collected data included age, gender, and year of graduation. Online osteopathic practitioners were recruited Australia-wide via an online forum. This online forum was sponsored by Osteopathy Australia, the osteopathic profession’s peak professional body. For the direct approach, ten osteopathic practitioners attending a local osteopathic educational meeting, were invited to participate.

The Test Instrument

To measure anatomy knowledge, a 20-question test instrument in a multiple-choice format was used that assessed knowledge of musculoskeletal (MSK) anatomy of the upper and lower limbs. This instrument had originally been developed and validated to assess the MSK anatomical knowledge of chiropractic students at Macquarie University in Sydney, Australia (Hulme et al., 2019). The test consisted of two components: 10 lower cognitive order (Low-order LO) questions requiring simple recall of anatomical detail; and 10 higher cognitive order (High-order HO) questions requiring analysis, application and integration of anatomy knowledge as it pertained to a clinical setting. The LO and the HO questions were evenly distributed throughout the test to improve compliance by avoiding participants’ becoming discouraged when encountering more difficult questions (HO) mid-test. The classification into two cognitive orders was based on the Blooming Anatomy Tool, a set of discipline specific criteria utilising Bloom’s Taxonomy that classifies cognitive levels of anatomy knowledge for multiple-choice questions (Anderson et al., 2001; Thompson and O’Loughlin, 2015; Morton et al., 2017; Day, 2018). Students were given the opportunity to participate in class with no prior warning to prevent biasing the results through pre-test preparation. Participating students were asked to keep the test questions confidential from other students. All data were de-identified.

Participant recruitment and Data collection

Student data were collected near the end of the 2020 academic year (November). Fourth- and fifth year-students were invited to participate during one

Table 3. Student cohort in new 4-year program & the old 5-year program.

Academic Year	Year 2	Year 3	Year 4	Year 5
2018	New 4-year course	Old 5-year course	Nil	Nil
2019	New 4-year course	New 4-year course	Old 5 -year course	Nil
2020	Nil	New 4-year course	New 4-year course	Old 5-year course

of their final classes for the year. They were informed that the test was not a summative assessment and did not count towards their final grade in the unit. Students were provided with a written copy of the test and given 20 minutes to complete it.

Osteopathic practitioners asked to participate in this study were recruited by both direct and indirect means. Direct means involved contact with the chief investigator at a local osteopathic educational gathering in 2019. Practitioners were invited to participate and provided with a hard copy of the test if they agreed to participate and provide consent. The indirect approach involved inviting practitioners to participate via an online discussion forum run by the national osteopathic association in 2020. Participation was voluntary and anonymous. There was no personal identification information collected from any of the participants as part of this study.

Statistical Analysis

Data were recorded and collated using MS Excel (Microsoft Corporation, version 16, 2016). All statistical calculations were performed using Statistical Package for Social Sciences (SPSS), version 23 (IBM Corp, Armonk, NY). Descriptive data, including means and standard deviations were calculated where appropriate. Mean scores were calculated for the correct number of low-order, high-order and total questions answered. Data were compared using paired t-tests. A p-value of less than 0.005 was considered statistically significant (i.e., using 0.5 % significance) for all analysis.

Ethics Approval

Ethics approval to collect data for this study was provided by two Human Research Ethics Committees (HRECs): Southern Cross University (approval number: ECN-14-242) and Macquarie University (Reference number: 52020907722092).

RESULTS

Participants

In total, 224 participants completed the questionnaires (106 students and 118 practitioners). For the students, this represented an 86.8% response rate (Table 4). According to the Australian Health Practitioner Regulation Agency (AHPRA), there were 2,546 registered osteopathic practitioners in Australia as of 30th of June 2018 (OBA, 2020). A total of 118 practitioners completed the questionnaire: 111 online and 7 paper-based, representing a response rate of 4.6% (118/2546).

Comparison of knowledge retention of students and practitioners

To ascertain whether there were differences between anatomy knowledge of osteopathic students, osteopathic practitioners, and chiropractic students at a different institution, knowledge retention was assessed using LO and HO questions. Using the independent-samples median test, scores were compared for the following (Tables 5 and 6):

1. Final-year osteopathic students in 2020: Year-four and Year-five.
2. Final-year osteopathic students in 2020 and osteopathic practitioners.
3. Year-5 final-year osteopathic students at SCU to Year-5 final-year chiropractic students at Macquarie University (MU).

Retrospective comparisons were also made with previous data of AKR among chiropractic students (Hulme et al., 2019) and compared with SCU students.

There were no differences between the fifth-year osteopathic students and fifth-year chiropractic students. All other comparisons revealed no differences in scores (LO, HO or total: LO + HO).

Age & Gender differences

There were no gender differences in any of the participant populations. There was a difference in the mean age of practitioners compared to both student groups (year 2 and year 5). While this is not surprising given, a practitioner in Australia would have to be of post-graduate age.

DISCUSSION

A major objective of educating health practitioners is the development of a sound knowledge -base which can be readily applied, integrated and synthesised to a clinical setting. The measurement of AKR can be used as a way of assessing whether this educational objective has been achieved. This study evaluated AKR in osteopathic students and osteopathic practitioners. The results demonstrated little attrition of knowledge amongst students and practitioners. Comparison between osteopathic and chiropractic students at a similar stage in their programs showed there was a difference in AKR.

Anatomy knowledge and program length

There were no differences in student mean scores, between the shorter four-year program and the longer five -year program at SCU implying students appeared to be equally effective in learning anatomy over a shorter duration. These results are not surprising as the new SCU anatomy curriculum was designed to be vertically integrated. This is consistent with the findings from similar studies (McBride and Drake, 2016; Wilson et al., 2018; Hulme et al., 2019; Zhao et al., 2020) that measured anatomy knowledge in medical students enrolled in an integrated problem-based learning curriculum (McBride and Drake, 2016; Wilson et al., 2018; Zhao et al., 2020), and chiropractic students enrolled in a standard program (Hulme et al., 2019).

The results from the present study provide evidence that graduates of a four-year osteopathic program are as ready to enter the health care workforce as those from a five-year program, with respect to their knowledge of MSK anatomy. This conclusion supports the change to a shorter program at SCU.

Table 4. Study participants.

<table>
<tr><th colspan="3">SCU Student groups</th><th rowspan="2">Participants</th><th rowspan="2">Response Rates (%)</th><th colspan="3">Mean age (years)</th></tr>
<tr><th>Program year</th><th>Academic Year</th><th>Number of students enrolled</th><th>Mean</th><th>Median</th><th>SD</th></tr>
<tr><td>5</td><td>2018</td><td>23</td><td>14</td><td>60.8</td><td rowspan="2">31.7</td><td rowspan="2">29.0</td><td rowspan="2">9.2</td></tr>
<tr><td>5</td><td>2019</td><td>27</td><td>25</td><td>92.6</td></tr>
<tr><td>4</td><td>2020</td><td>24</td><td>24</td><td>100.0</td><td>32.0</td><td>33.3</td><td>8.4</td></tr>
<tr><td>5</td><td>2020</td><td>32</td><td>29</td><td>90.6</td><td>35.0</td><td>33.0</td><td>9.9</td></tr>
<tr><td>Total</td><td></td><td>106</td><td>92</td><td>86.8</td><td colspan="3"></td></tr>
<tr><th colspan="8">Practitioners</th></tr>
<tr><td colspan="2">Osteopathic Practitioners</td><td>Potential Participants*</td><td></td><td></td><td colspan="3"></td></tr>
<tr><td>Online, remote</td><td>2018</td><td>2546</td><td>111</td><td>4.6</td><td rowspan="2">37.7</td><td rowspan="2">37.0</td><td rowspan="2">9.2</td></tr>
<tr><td>Paper-based</td><td>2018</td><td></td><td>7</td><td></td></tr>
<tr><td colspan="2">Total practitioners</td><td></td><td>118</td><td></td><td colspan="3"></td></tr>
</table>

*= total number of Australian osteopathic practitioners registered with OBA 2018

Table 5. Summary of knowledge retention comparisons by group.

<table>
<tr><th rowspan="2"></th><th colspan="4">Academic year</th></tr>
<tr><th>2018</th><th>2019</th><th>2020</th><th>2020</th></tr>
<tr><td>4th year students vs
5th year students</td><td></td><td></td><td>year 4 (n=24)</td><td>year 5 (n=29)</td></tr>
<tr><td>Osteopathic students vs Osteopathic practitioners</td><td>Practitioners (n=118)</td><td></td><td>year 4 (n= 24)</td><td>year 5 (n=29)</td></tr>
<tr><td>Osteopathic students vs Chiropractic students</td><td>year 5 (n=14)</td><td>year5 (n=25)
*year 5 (n=44)</td><td>year 5 (n=29)</td><td></td></tr>
</table>

* indicate chiropractic students from Macquarie University (raw data obtained from Hulme et al., 2019). All other students are from SCU.

Table 6. Summary of comparison of AKR in students and practitioners.

Cohorts	LO			HO			Total (LO + HO)		
	Mean (x/10)	SEM	SD	Mean (x/10)	SEM	SD	Mean (x/20)	SEM	SD
SCU Year 4 students	6.0	0.39	1.9	3.5	0.26	1.3	9.6	0.54	2.6
SCU Year 5 students	6.3	0.29	1.5	3.6	0.24	1.3	10.1	0.36	1.9
P values [a]	0.996			0.962			0.966		
SCU Year 4 students	6.00	0.39	1.9	3.5	0.26	1.3	9.6	0.54	2.6
SCU Year 5 students	6.31	0.29	1.5	3.6	0.24	1.3	10.0	0.36	1.9
Practitioners	6.10	0.19	2.1	4.4	0.13	1.4	10.6	0.28	3.0
P values [a]	0.671			0.089			0.494		
Practitioners < 10 years since graduation	6.12		2.1	4.2		1.26	10.33		2.76
Practitioners ≥ 10 years since graduation	6.25		2.2	4.6		1.59	10.88		3.30
P values [b]	0.744			0.111			0.340		
SCU Year 5 students	5.5		1.8	4.5		1.3	10.0		2.5
MU Year 5 students	5.5		1.7	4.4		2.0	9.9.		3.0
P values [c]	0.968			0.834			0.876		

[a] p values using Independent-Samples Median Test; [b] p values using Two sample t-tests; [c] p values using Two sample-t tests, appealed to Central Limit Theorem.
AKR= anatomy knowledge retention; SCU = Southern Cross University; MU = Macquarie University; * = significant difference ($p<0.0005$). LO: Low order; HO: High order

The results can be explained by the configuration of the new four-year program with its integrated curriculum where biomedical and clinical sciences are taught within a more clinically oriented context (Brauer et al., 2015; Johnston and Vaughan, 2020). Although there is still a predominance of biomedical sciences in the early years of the program followed by clinical learning in the later years (Craig et al., 2010; Talarico and Painter, 2020), the integrated approach includes clinical context for the content covered in the earlier years so as to enhance learner engagement and content retention (Erkonen et al., 1992; Norman, 2009; Bridges et al., 2016; Quintero et al., 2016; Farey et al., 2018).

AKR in osteopaths

It was expected that there would be difference in AKR between students and practitioners and that anatomy knowledge attrition would increase with length in time in practice (Bakkum and Trachomowicz, 2015). Surprisingly, there were no differences in AKR between osteopaths and senior students and no attrition of anatomy knowledge in osteopaths. The findings of the present study contradict findings from other studies that investigated AKR in health practitioners (Custers and Cate, 2011; Bakkum and Trachimowicz (2015). These studies demonstrated decreasing AKR over time. Bakkum and Trachimowicz (2015) studied knowledge of the microanatomy of the retina in fourth-year optometry students (n=35), optometry faculty members (n=41) and optometrists in private practice (n=96), and found a steady and consistent trend of knowledge attrition with years from graduation. The longer the private practice optometrists had been in practice, the less retinal layers they were able to correctly identify.

In a study of AKR in medical students (n= 25) and practicing doctors (n=25; junior doctors: n=15; senior doctors: n=10), the doctors were able to correctly identify more of the carpal bones compared to the medical students (Spielmann and Oliver, 2006). Furthermore, the senior doctors with more clinical experience performed better than the medical students and junior doctors. This is to be expected, although caution is advised, as this study used a very small sample size and the carpal bones test is a crude and very limited measure of anatomy knowledge. A study also using the carpal bones test found similar results (i.e., poor AKR) in medical graduates (n=102) undertaking specialty-training in Accident & Emergency medicine, or trauma/orthopaedics (Roche et al., 2011).

The discrepancy in results from these studies and the present study can be explained by the different anatomy knowledge measurement tool used. The present study used the MSK anatomy knowledge test, which is a more comprehensive measurement of anatomy knowledge compared to the narrow carpal bone test, which is limited in its ability to measure anatomy knowledge.

Using a knowledge test covering a range of basic biomedical sciences including anatomy, physiology, biochemistry, and pathophysiology, a long-term study of medical students (n=65) and medical practitioners (n=75) reported better performances by students compared to practitioners with length in practice a contributing factor (Custers and Cate, 2011). Similarly, licensed physical therapists (n=182) scored better than physical therapy students on the BCE tool (Childs et al., 2005), supporting the concept that there is a difference between anatomical knowledge and clinical competency with that knowledge (Jassen et al., 2014). In an Australian study that also used the BCE to measure MSK knowledge in general practitioners (n=47) and orthopaedic interns (n=66), general practitioners scored higher (Broadhurst et al., 2002). These results are to be expected as the BCE assesses clinical management as well as MSK anatomy knowledge and general practitioners had experienced broader clinical management than the orthopaedic interns. Taken together the choice of test may be a factor in determining results in an AKR test and could explain the difference in results in the present study. The context of the curriculum and the emphasis placed on the learners' perception of the relevance of the anatomy being taught may also affect the level of AKR (Bergman et al., 2014).

Comparison between osteopathic and chiropractic students

As there are many similarities between the scope of practice of chiropractic and osteopathy, it was considered appropriate to compare AKR among students from the two professions. Both professions focus on the MSK system and related disorders and share a common reliance on manual therapy as an intervention. Data on AKR in chiropractic students at MU has been reported in the literature and was made available to the researchers (Hulme et al., 2019). Data from fifth-year chiropractic students at MU was compared to performances with fifth-year osteopathic students at SCU.

There were no differences in AKR between the fifth-year osteopathic and chiropractic students. It was anticipated that both fifth-year student cohorts would perform similarly in the AKR test, as these students were at the conclusion of their formal studies and about to enter the workforce as health practitioners.

Both programs included integrated curricula (Hulme et al., 2019) and both had received full accreditation by the relevant accrediting bodies. The difference in AKR in students could be attributed to the anatomy syllabus component of the new osteopathic (four-year) program.

Our findings are consistent with similar comparisons of AKR in students in other health professions. These include studies using the carpal bone test in fifth-year Australian chiropractic students (n=44), who did much better than second-year chiropractic students (n=47) (Meyer et al., 2015); fifth-year chiropractic students (n=84) who did much better than final-year medical students (Strkalj et al., 2011); and third-year Spanish physical therapy (PT) students (n= 54) who did better than third-year Spanish medical students (n=80) (Valenza et al. (2012). Contradicting these results, Dayal et al. (2017) found that first-year Australian physiotherapy students (n=129) were better at correctly identifying the carpal bones compared to their fourth-year (n=113) counterparts. In a study of Spanish podiatry students (first-years n=145 and fourth-years n=109), Castillo-Lopez et al. (2014)

found no difference in anatomy knowledge when using the tarsal bones test. These conflicting findings can be explained by the use of different tests, both of which are a narrow measure of AKR that is not indicative of other components of anatomy knowledge.

Limitations

It is important to state that AKR as measured in the present study does not equate to clinical competency. Even though HO questions were included, these questions do not give any indication of clinical competency. Measuring clinical competency is more complex than measuring AKR (Miller 1990; Wass et al., 2001). The format and nature of anatomy assessment can strongly influence anatomy learning and AKR (Logan et al., 2011; Bergman et al., 2014). This study did not include how anatomy was assessed within the programs, or the timing of anatomy assessments.

This study only measured AKR and did not investigate the factors which could influence AKR. Further studies should include focus groups with osteopathic students to discuss factors in anatomy learning that they consider important to improve AKR and better prepare them for clinical practice (Bergman et al., 2014; Farey et al., 2018). These factors could then be used by curricula planners to improve anatomy learning outcomes.

All data gathered as part of this study was cross-sectional in nature. Longitudinal data of AKR would provide more methodological rigour and validity. Measuring AKR in the same student cohorts at multiple time points would help to achieve this.

This study was not designed to be a comprehensive assessment of all AKR at a single educational institution (e.g., SCU). The test instrument used in this study was limited to only measuring MSK anatomy knowledge. Other aspects of the anatomy curriculum were not measured such as the sub-disciplines visceral anatomy, spinal anatomy, microanatomy (histology), developmental anatomy (embryology), neuroanatomy, and radiographic anatomy. Measuring what constitutes a passable or satisfactory mean test score, or what level of anatomy knowledge could be considered as ample for safe and effective osteopathic clinical practice were considered beyond the scope of this study and therefore not identified.

As participation in this study was voluntary and did not from part of the formal anatomy assessments, the number of participants in the various student cohorts may not be representative of the entire student cohort. As all data used in this study was obtained anonymously, it was not possible to measure an individual's performance over time with only mean scores used for comparisons. The small student sample sizes are a result of the small number of students enrolled in the osteopathic programs at SCU and could be considered a limitation with respect to the generalisability of these results.

The study also used a small number of MCQs as the knowledge retention assessment tool.

The theory-based MCQs are easy and quick to mark, eliminate potential bias, and increase inter-examiner reliability. This tool may not thoroughly assess anatomy knowledge and it is recommended that a more comprehensive set of questions be used in future studies in order to assess anatomy knowledge more thoroughly.

Future Directions

As these results may not be comparable with other educational institutions, further investigations could include conducting similar studies at other osteopathic educational institutions in Australia and overseas to validate these findings on a broader scale. Additionally, expanding the scope of assessments to include other parts of the anatomy curriculum, e.g., visceral anatomy, spinal anatomy, histology, embryology, and neuroanatomy, would improve our understanding of anatomy knowledge retention. To improve anatomy knowledge amongst students, others have suggested the addition of anatomy instructions where students revisit key anatomical concepts so as to improve their ability to transfer anatomy knowledge to a clinical setting (Lazarus et al., 2012; Jurjus et al., 2016).

CONCLUSION

There is a consistent level of anatomy knowledge retention among Australian osteopathic students and practitioners. Shortening the length of an osteopathic program does not appear to affect the level of musculoskeletal anatomy knowledge in graduating students in a vertically integrated curriculum. The results from the present study can assist in informing the development of a core anatomy curriculum for osteopathic education within the Australian context, and can also contribute to the standardisation of a minimum level of anatomy knowledge required for students entering clinical practice.

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