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Anatomical Sciences in Chiropractic Education:

A survey of Chiropractic Programs in Australia

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ABSTRACT

Human anatomy knowledge is a core requirement for all health care clinicians. There is a paucity of information relating to anatomy content and delivery in Australian chiropractic programs. The aim of this study was to describe anatomy teaching in Australian chiropractic programs, utilizing a survey which was distributed to all four programs, requesting information on: anatomy program structure, delivery methods, assessment, teaching resources, and academic staff profile at their institution. The survey was undertaken in 2016 and documented practices in that academic year. All four institutions responded. There was a reported difference in the teaching hours, content, delivery and assessment of anatomy utilized in Australian chiropractic programs. Anatomy was compulsory at all four institutions with the mean total of 214 (SD ±100.2) teaching hours. Teaching was undertaken by permanent ongoing (30%) and sessional academic staff, and student to teacher ratio varied from 15:1 to 12:1. A variety of teaching resources were utilized, including human tissue access, either as prosected cadavers or plastinated body parts. The results of this survey confirm that anatomy has an established place in chiropractic education programs in Australia and whilst curricular variations exist, all programs had similar course design, delivery and assessment methods. This study confirmed the provision of a strong foundation in topographical anatomy and neuroanatomy, whilst other anatomical sciences such as histology and embryology were not consistently delivered. Formalization of a core anatomy curriculum together with competency standards is needed to assist program evaluation and development, and for accreditation purposes.

Key words: gross anatomy education; chiropractic education; undergraduate education, Australia; anatomy curriculum; survey

INTRODUCTION

The World Federation of Chiropractic defines chiropractic as "a health profession concerned with the diagnosis, treatment and prevention of mechanical disorders of the musculoskeletal system, and the effects of these disorders on the function of the nervous system and general health, with an emphasis on manual treatments including spinal manipulation or adjustment" (WFC, 2019). Since the disciplines' inception in the late 19th century, anatomy has been foundational in the training of its practitioners. In spite of this and in contrast to the vast body of knowledge on anatomy education in medical curricula globally (Cottam, 1999; Drake et al., 2002; Gartner, 2003; Drake et al., 2009; Craig et al., 2010; Drake, 2014), there is a paucity of studies that have explored biomedical sciences education in allied health professional programs both in Australia and elsewhere (Coulter et al., 1998). With respect to chiropractic programs, there is a deficit in understanding in both the breadth and depth of the biomedical sciences content required to meet the minimum standards for clinical competence. It is becoming apparent that an understanding and appreciation of the anatomy content required in chiropractic programs is a necessity for educators and regulators, and may further facilitate interprofessional confidence between health disciplines (Smith et al., 2015) and provide an early avenue for developing interprofessional teamwork.

Chiropractic Profession in Australia

The establishment of the chiropractic profession in Australia can be traced back to the teaching of spinal manipulation which commenced in the 1930's in Victoria, and subsequently in 1959 in New South Wales and in 1962 in South Australia (Devereaux et al., 2006). However, it was only in 1970 that a chiropractic discipline-specific program was established in Sydney, New South Wales by The Sydney College of Chiropractic. Similarly, in 1973 a second chiropractic program was implemented at Preston Institution of Technology

in Victoria, which later became the Phillip Institute of Technology (PIT) (Bolton, 2010). In 1991, The Sydney College of Chiropractic merged with Macquarie University, a government funded university in the north-western suburbs of Sydney (Ebrall and Takeyachi, 2004; Bolton, 2010), and thus established the first chiropractic program at a government-funded public university in the world.

The chiropractic profession in Australia was first licensed (or registered) as an independent health profession in 1978, which permitted chiropractors to practice autonomously and without the need for a referral from a medical or other health practitioner. The next significant landmark in the development of the chiropractic profession in Australia was its inclusion in the National Registration and Accreditation Scheme (NRAS) established in 2010, representing 14 (20%) Australian accredited health professions including chiropractors as well as dental practitioners, medical practitioners, nurses and midwives, optometrists, osteopaths, pharmacists, physiotherapists, podiatrists and psychologists (AML Alliance, 2013). In 2016, when the Australian population was estimated to be 24.4 million, allied health practitioners numbered over 220,000 in Australia (AIHW, 2016) of which 5,167 were registered chiropractors (AHPRA, 2016) with wide public uptake of services estimated to be approximately 21.3 million chiropractic patient services per year (Adams et al., 2017).

Role of chiropractic in the health care workforce

In Australia, as in the rest of the world, the rapidly ageing population has resulted in an increased demand on primary health care services directly addressing non-communicable diseases (Murray et al., 2010; WHO, 2015), which has led to a considerable increase in health care expenditure. The chiropractic profession in Australia is well poised to assist the health care system by providing conservative treatment options for the management of spine and

musculoskeletal conditions such as joint pain, low back and neck pain. The presence of these conditions can negatively impact mobility and independence and increase the risk of other non-communicable health conditions such as obesity and cardiovascular disease (Briggs et al., 2016).

The primary treatment modality used by chiropractors is conservative manual therapy comprising joint manipulation and mobilization (Bronfort et al., 2004; Bronfort et al., 2010; Kosloff et al., 2013). In addition, chiropractors provide rehabilitation programs and contribute to patient education as part of a broader health care strategy. Chiropractic (manipulative therapy) is recommended as a first line treatment in several evidence-based guidelines for the management of spine and musculoskeletal conditions (Chou et al., 2007; Dagenais et al., 2010; Koes et al., 2010) and is reflective of a trend towards a multidisciplinary approach to patient-centered care that shares the care of a patient with the most appropriate health professional (Ho et al., 2008).

In Australia the increased uptake of chiropractic services is due to the growing ageing population as well as a higher regard for graduate capabilities, professional regulation, government legislation, inclusion in private health insurance coverage and individual patient preferences (Engel et al., 2014).

Chiropractic accreditation and degree structure

The transition of chiropractic education from private colleges to government-funded universities has ensured the adoption of robust evidence-based pedagogical practices (Delaney and Fernandez, 1999; Johnson and Green, 2010; Štrkalj et al., 2012b; Walker, 2016; Whillier et al., 2019) with oversight from an accreditation body. In Australia, at present, there

are four chiropractic programs all accredited by the Council on Chiropractic Education Australasia (CCEA) (Table 1).

In Australia, obtaining a chiropractic qualification requires completion of either an undergraduate Bachelor plus Masters Degree or a double Bachelors Degree from an accredited program. This usually requires a minimum of five years full-time study at one of the four government funded, public universities offering chiropractic programs (Table 1). Regulation of chiropractic education in each major region of the world (US, Canada, Europe, East Asia, and Australia) is the responsibility of an accreditation body (Ebrall and Takeyachi, 2004) which is part of a larger federal government regulatory body responsible for maintaining standards of education. The CCEA provides guidelines for the minimum accreditation standards applicable to chiropractic programs, it does not provide any detailed recommendations for the anatomy content or its delivery within the chiropractic programs (Štrkalj and Casey, 2013).

Anatomy teaching in Australian chiropractic programs

Anatomy is foundational in the training of chiropractic professionals. As with other primary contact health professions, a chiropractic clinical consultation includes patient history taking, physical examination, consideration of medical imaging/test reports, followed by diagnosis and initial management. Chiropractors are trained to provide education and advice to assist with management of musculoskeletal conditions, and, if required refer for further investigations and/or consultation (Turney, 2007; Štrkalj et al., 2011; McHanwell and Smith, 2012). A comprehensive knowledge of anatomy is needed to underpin all aspects of the clinical consultation, arguably equal to that required by a general medical practitioner (Brinkley et al., 1997; Paalman, 2000; Lachman and Pawlina, 2006; Yammine, 2014).

In addition, a well-designed anatomy curriculum has been recognized for its role in developing appropriate professionalism, communication skills and a patient-centered teamwork approach in chiropractic care, as in other disciplines (Netterstrøm and Kayser, 2008; Hopkins et al., 2011; Moxham, 2014). The teaching of anatomy can evoke an increased sense of humanity (Rizzolo et al., 2010; Štrkalj et al., 2014), as well as encourage students to realize a commitment to assume responsibility for a whole-of-person approach (Jones, 2017; Štrkalj and Pather, 2017), which is an essential requirement in training all health care professionals and producing safe and effective practitioners (Patel and Moxham, 2008; Moxham, 2014). Teaching anatomy to future clinical professionals requires the inclusion of relevant and comprehensive knowledge-based competencies in all the anatomical sciences such as embryology, histology and neuroanatomy. Vertical and horizontal integration of anatomy within curricula enhances the application of foundational knowledge alongside the delivery of other biomedical sciences and clinical disciplines which further enriches the development of clinical reasoning (Brauer and Ferguson, 2015).

Aim of the study

The aim of this study was to analyze the current practice of anatomy education in all four chiropractic programs available in Australia.

METHODS

Participants

The Heads of School of all four Australian chiropractic programs were contacted to participate in the study. All four of the institutions agreed to participate in this study.

At the time of the survey, all four chiropractic programs were accredited by The Council on Chiropractic Education Australasia (CCEA). For reporting and as a requirement of the ethics

approval for this study, each institution was de-identified, order randomized, and then assigned a number (i.e. Institution 1 to 4).

The survey tool

The survey tool to collect data on the anatomical education practice in all four chiropractic programs was based on previously published survey tools for assessment of anatomy education across institutions (Drake et al., 2002; Ball et al., 2012; Drake et al., 2014). A draft version of the survey was pre-tested using experts (anatomy educators in the health care field) with a view to maximizing readability and decreasing question ambiguity.

The final survey comprised 13 items with a target 15-20 minute completion time (Supplementary Material Appendix 1). The survey was electronically distributed to the Heads of Chiropractic Departments requesting participation and permission to disseminate the questionnaire to the anatomy academic staff responsible for the anatomy courses in their chiropractic program. In this paper, the term 'course' is used to refer to the unit of study that students undertake as part of the curriculum in the chiropractic program. The survey was approved by the Human Research Ethics Committee of UNSW, Sydney (HC16447).

Reporting and analysis

The data were extracted, collated and verified for accuracy by two independent authors (R.G., G.S.) using Microsoft Excel, version 16.2 (Microsoft Corp., Redmond, WA). Where relevant, the data were summarized using descriptive statistics (mean and ±standard deviation).

Internal consistency of survey items was calculated using a Cronbach's alpha with acceptable values ranging from 0.7 and 0.9. An alpha < 0.7 could reflect poor interrelatedness between questions or heterogeneous constructs. Likewise, an alpha > 0.9 may indicate that some questions are redundant (Tavakol and Dennick, 211). Statistical analysis was completed using SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY).

RESULTS

Survey Response

All four institutions offering Chiropractic programs returned completed surveys. Participants responded to all items in the survey tool except for one institution which responded to 12 of the 13 survey items. The survey responses had good internal consistency (Cronbach's alpha = 0.86).

The anatomy: Chiropractic relationship

In order to establish where the responsibility and oversight of the anatomy content in the chiropractic programs was, participants were asked to indicate whether the responsibility for delivering the anatomy courses belonged to the Chiropractic Department/School at their respective institutions. Anatomy courses were administered at Institution 1, jointly by the Chiropractic and other Departments at Institution 3; and Departments independent of the Chiropractic program at Institutions 2 and 4.

The survey results demonstrated that all chiropractic students in Australia were exposed to an interdisciplinary or 'shared' learning environment while undertaking the anatomy courses. This was because the anatomy courses undertaken by chiropractic students in all the programs were consistently co-delivered to students from a variety of disciplines; most

frequently from science (Institutions 1 and 3), Osteopathy and Chinese Medicine (Institution 2), and biomedical physiology (Institution 4). Chiropractic students in anatomy courses comprised 29% (Institution 1) to 85% (Institution 4) of the cohort studying anatomy together. At all four institutions, anatomy is a compulsory course in the first degree, and additionally also delivered as an independent course in the second degree at one institution (Institution 3).

The anatomy: Medical science relationship

Participants responded to a series of questions designed to determine the relationship of the anatomy courses to other biomedical science courses delivered in the chiropractic programs. Three programs reported that the anatomy courses were independent courses, while in one program, anatomy was both independent and integrated within other courses such as the chiropractic disciplines (Institution 3). Although taught independently, the survey responses demonstrated that anatomy content delivery was aligned with that of other medical sciences such as physiology at three of the four institutions (Institutions 1, 3 and 4). This differed from the integration of anatomy delivery with that of the clinical sciences, with the institutions reporting either: no alignment (Institution 3); delivery within clinical courses (Institution 1); or integrated delivery "where relevant" (Institution 4). Institution 2 did not respond to this item of the survey tool.

Anatomy: Modes of delivery and teaching hours

In order to establish what modes of delivery were used in the anatomical sciences education, participants responded to survey items on modes of delivery (face-to-face and online), and teacher contact hours with students in each of these modes. In this study, online content hours refers to mandatory learning activities made available electronically, e.g. via the electronic learning management system, that students complete in their own time, and at their own pace.

The total number of anatomy teaching hours was calculated as a sum of the reported face-to-face and mandatory online hours across all anatomy courses and excluded the time allocated for assessment activities. For this computation and for ease of comparison, only courses with exclusively anatomy content were considered. The mean total number of anatomy contact hours excluding assessment was 214.0 (SD ±100.2) hours with a range of 156 hours (Institution 2) to 364 hours (Institution 1). All chiropractic programs delivered anatomy content to students via both lecture and practical/laboratory sessions (Table 2).

Three of the four chiropractic programs offered both face-to-face and online delivery of anatomy content, with no online delivery methods utilized at Institution 2. Institution 3 reported that anatomy was also embedded into three additional clinical chiropractic units, (excluded from calculation of total anatomy hours delivered). Three of the institutions (Institutions 2, 3, and 4) offered very similar hours of anatomy instruction with a mean of 164.0 (SD ± 6.9) hours. Institution 1 delivers the greatest amount of face-to-face instruction (312 hours), compared to other institutions (range: 48-156 hours). This is due to greater amount of face-to-face delivery in practical/tutorial sessions. Institution 1 also reported the greatest number of total hours of anatomy delivery. In comparison, Institution 3 delivered anatomy content using online delivery methods for all lecture delivery and for a greater number of its contact hours than face-to-face delivery. This Institution also provided more contact delivery using online methods than any of the other three programs.

Content delivery and assessment methods in anatomical sciences

Anatomy content delivery for each of the anatomical sciences (i.e., gross anatomy, histology, embryology and neuroanatomy) and assessment methods were analyzed in each of the four programs. All Australian chiropractic programs included topographical (gross) anatomy and

neuroanatomy, however, not all institutions delivered content of histology and embryology. Three institutions confirmed that embryology is taught (institutions 1, 3 and 4) as part of the anatomy content and at two of these (Institutions 1 and 3) histology was also taught (Table 3). All four institutions included neuroanatomy in their content delivery, with two institutions confirming that neuroanatomy was an independent course (Institutions 1 and 3). Across all institutions, there was a total of 15 gross anatomy courses, 12 neuroanatomy courses, 7 embryology courses and 3 histology courses taught.

In addition to practical and written assessment methods used by all institutions, three of the four institutions also reported using other assessment methods (Institutions 1, 2 and 3) (Fig. 1). 'Other' assessment activities included quizzes delivered during tutorial sessions, and this contributed between 16% to 25% of the final course grade (Fig. 1). The contribution of the practical assessment activities to the course grade was weighted higher at Institution 4 (67%) when compared to that of the other three institutions, whose written assessment activities had a greater contribution (ranging from 40% to 58%) to the final grade (Fig. 1).

Anatomy: Learning resources

All institutions provided students with access to a variety of resources to support student learning (Table 4). Models and interactive anatomy software were uniformly used across all institutions. None of the institutions provided the students with the opportunity to undertake cadaveric dissection, though three of the four institutions used human cadaveric prosections. Only one institution (Institution 1) provided students with 3D printed models along and locally produced videos. Only two of the four institutions confirmed the use of a repository of medical images as a teaching resource, indicating that radiology is not extensively utilized in teaching anatomy.

Anatomy: Faculty and staff

Participants were asked to respond to a series of questions to ascertain the nature of the faculty delivering anatomy teaching. There were some differences between the four institutions in the number, academic status and qualifications of the anatomy teaching staff (Table 5). The number of academic staff was proportional to the number of students in the respective programs. In addition, three of the four institutions (Institutions 1, 2 and 4) reported the same student: teacher ratio (15:1), while one institution reported a ratio of 12:1 (Institution 3) which was also the institution that did not offer face-to-face lectures. As Australian academic staff have several differing university appointment categories, this was an important aspect of the staff profile to examine. Each program was asked to list the number of academic staff according to the following categories: (1) permanent appointments (equivalent to tenured university staff); (2) sessional staff (usually qualified staff on limited-term contracts); and (3) senior student tutors/casual staff, who are usually senior students who have not yet graduated, and on limited employment contracts to deliver teaching. At all institutions, the permanent staff held PhDs and/or Masters level qualifications while sessional staff held at least an Honors Degree. Across all institutions and across all appointment categories, 28 (93%) academic staff members held either a Masters or a PhD degree qualification. Across all institutions, permanent staff made up 30% of the total staff involved in teaching.

Analysis of permanent academic staff numbers who also held chiropractic qualifications varied across the four institutions: Institutions 2 and 4 had none, Institutions 1 and 3 had one and two, respectively. All academics with chiropractic qualifications held Masters level chiropractic degrees.

DISCUSSION

This study is the first to describe the profile of anatomy teaching in Australian chiropractic programs. The study demonstrates that anatomy education is an integral component in all four Australian chiropractic programs. The delivery of anatomy across programs was similar despite differences in student enrollment numbers, program structure and faculty qualifications. Anatomy was a compulsory component in the first- or undergraduate-degree component of the chiropractic programs in all four institutions and is thus comparable to that previously seen in many medical programs where anatomy is taught in the first years of the program as a foundation or precursor to clinical units and clinical training in the later years (Smith et al., 2016).

The survey demonstrated that in the anatomy-only courses required for the chiropractic qualification in Australia, chiropractic students were not always the majority of the cohort (range: 29% [Institution 1] to 85% [Institution 4)]). Notwithstanding, this presents a challenge to customizing the content delivery, and while it is unclear whether this is an intentional effort to develop interdisciplinary collaborative learning communities, it can be argued that anatomy presents the earliest opportunity to embed inter-disciplinary team learning (Giuriato et al., 2016). This opportunity can be utilized to enhance skills such as communication, which will be required in clinical practice post-graduation (McBride and Drake, 2015) as well as provide opportunities to develop an awareness of interprofessional teamwork which can impact later professional collaboration (Jones, 2010; Pawlina and Drake, 2016). The benefits of student diversity in the anatomy cohorts may also assist students to acknowledge the level of anatomy competency in other health care professionals and thereby begin the process of developing inter-professional respect and trust (Hamilton, 2008) that is essential in the collaborative context of patient-centered health care.

The diversity of students undertaking anatomy at each of the four institutions, irrespective of whether the anatomy program was administered by the Chiropractic Department, suggests that the anatomy courses may not be specifically tailored for chiropractic graduates. Delivering anatomy courses to multiple student cohorts simultaneously, whilst efficient from an institutional economic perspective, may present a challenge in providing content specifically tailored to a particular profession's needs. In this context, an agreed anatomy core syllabus for the profession would be invaluable for the anatomy course designers. However, while there are initiatives to establish an agreed core syllabus for anatomy, its successful implementation will require support from both chiropractic departments and accrediting bodies to ensure that faculty are able to deliver what is required for chiropractic students (Patel and Moxham, 2008). Indeed, this is a challenge that is not dissimilar to that also faced by medical curriculum designers (Pabst et al., 2001; Turney, 2007; Goulston and Oates, 2008).

Course content

Historically, and internationally, the chiropractic profession has debated what constitutes evidence-based practice in the profession, with early efforts focused on blending traditional belief systems (e.g. vitalism) with scientific theories (Gatterman, 1995). However, in Australia, all chiropractic programs are required to deliver program content informed wholly by contemporary research and evidence-based practice (Sackett et al., 1996; Haneline, 2011; Murphy et al., 2011, Schneider et al., 2016). This extends to include a range of foundational science units within the chiropractic curricula. The variation in the number of anatomy courses in each program (range: 2 to 7 courses), and the variability in the modes of delivery and teaching hours may be reflective of the lack of clear guidelines related to anatomy in the program accreditation standards, especially in the absence of an agreed anatomy core

syllabus or a common barrier examination for chiropractic programs in Australia. This is unlike the current practice in medicine in Australia (Chapuis et al., 2010; Chapman et al., 2015).

The face-to-face teaching hours (excluding assessment activities) across all four of the chiropractic institutions surveyed (mean total: 214 hours; Table 2) in this study was greater than the previously reported total mean anatomy hours: 171 hours for 19 Australian medical programs (Craig et al., 2010). One possible explanation for this difference is that medical programs have adopted integrated curricula (Brauer and Ferguson, 2015), which has made quantifying hours for any single discipline difficult. In addition, medical curricula have incorporated new knowledge from disciplines such as cellular biology, medical imaging and informatics, and public health which has the potential to reduce the amount of time available or delivery of anatomy content. The difference between anatomy delivery in Australian chiropractic and medical programs is similar to that of medical and osteopathy programs in the United States (Drake et al., 2014) and in the United Kingdom and Ireland (Smith et al., 2015), where medical programs have also moved away from the discipline-based approach to a multi-discipline integrated approaches (Drake et al., 2009). In this respect, Australian chiropractic programs have followed the trend to include anatomy as a 'spiral' throughout the program (Harden and Stamper, 1999). For example, this study has shown that topographical anatomy is typically revised within other units later in the curriculum (for example within radiology, orthopedics, neurology, and chiropractic technique courses). However, the depth and/or integration of anatomy content within other disciplines was not explored further in this study.

This study found that the majority of chiropractic programs aligned anatomy content with other biomedical disciplines such as physiology. This may be useful in increasing students' ability to interpret anatomical structure and function with clinical relevance (Hartley et al., 2018). This study also found that while all institutions provided a strong foundation in topographical anatomy and neuroanatomy, other anatomical sciences such as histology and embryology were not always delivered (Table 3). It is unclear if these anatomical sciences are covered in other areas of the chiropractic curriculum but if not, may be considered a serious omission (content gap) given the importance of these anatomical sciences in understanding human-development, function and pathological disease states, and their effects on musculoskeletal health. In addition, for chiropractors to remain current and to provide informed patient education, they must be able to participate in the research discourse which increasingly requires an understanding of cellular structure and a sound foundational knowledge of histology and embryology. The content gap identified by this study must be addressed and is arguably where an agreed and relevant core syllabus would be useful to chiropractic curriculum development stakeholders.

Teaching resources (including faculty)

In addition to didactic lectures and practical/laboratory sessions, this study identified various teaching modalities used in each institution. These included the use of prosected and plastinated cadaveric specimens, anatomy models including 3D printed versions, interactive software, medical images, electronic anatomy atlas and even locally produced teaching videos. The use of such a varied number of learning tools is consistent with anatomy teaching in medical programs and assists to promote active learning (Peterson and Mlynarczy, 2016; Peeler et al., 2018) and are reflective of fit-for-purpose learning resources (Estai and Bunt, 2016). The access to varied learning resources permitting students to identify structures and

relate concepts has been shown to enhance student satisfaction (Lim et al., 2008; Topping, 2014; Štrkalj et al., 2018) and improve knowledge retention (Louw et al., 2009; Sugand et al., 2010; Zumwalt et al., 2010) by appealing to the different student learning styles (Drake, 2014).

None of the institutions provided students with the opportunity to undertake direct cadaveric dissection, a teaching tool previously used for centuries (Estai and Bunt, 2016) . This is unsurprising given the cost and limited access to cadavers in Australia, which is similar for students in medical programs. This is not necessarily of great concern as prosections have been shown to provide an equally valuable experience if implemented correctly (Pather, 2015) and similarly to dissection, provide opportunities to instill professional skills and attitudes in students (Polly et al., 2017).

All anatomy units in Australian chiropractic programs are delivered by tenured staff with PhD qualifications, in compliance with the Australian Tertiary Education Quality and Standards Agency (TEQSA) Act 2011 recommendations, which is an agency established to ensure the highest academic quality and standards in Australian higher education institutions (TEQSA, 2011). In particular, satisfying TEQSA standards of academic teaching staff having at least one level of higher than-the-course of study being taught qualification (TEQSA, 2011). This study also demonstrated that all chiropractic programs provided sufficient staffing to meet the educational needs of the student cohorts undertaking anatomy courses. The academic staff-student ratio was mostly consistent among the four institutions (1:15) with up to 19 anatomy academic staff employed at Institution 1 (Table 5).

Even though not all students taking the anatomy units were studying chiropractic, two institutions exposed the students to anatomy staff who held chiropractic qualifications. While not evaluated for Chiropractic specifically, the benefits of engaging teaching staff with a variety of qualifications and clinical expertise potentially augments vertical and horizontal integration in health care professional curriculum (McMenamin et al., 2016). Similarly, cross-pollinating anatomists into other professional units has been shown to strengthen anatomy integration into the clinical units (McMenamin et al., 2016).

While many medical programs have moved away from teaching anatomy in discreet units or aligned only with specific courses such as physiology, to a fully integrated delivery approach. In contrast, this study found that within chiropractic education in Australia, the biomedical sciences education was predominantly as discrete discipline knowledge toward the end of the degree program in the clinical internship years. In this model, chiropractic students first learn discipline content and then apply and integrate this knowledge in a clinical setting in later years of the program. Anatomy in the later years is integrated through courses which deliver chiropractic technique, neurology, orthopedics, radiology, differential diagnosis, and patient management leading to work integrated learning environments (clinic).

Future direction

As data relating to anatomy education within chiropractic programs worldwide is limited, it would be useful to compare this Australian chiropractic anatomical sciences education profile with similar profiles in other regions of the globe. In addition, the concept of a core anatomical science syllabus is not new, especially in the purvey of medical education (Parkin and Standring, 2016). Over the past few decades since the Flexner Report (Flexner, 1910), numerous investigations of anatomy teaching in medicine programs have been undertaken

with respect to content, teaching modalities, sequence of delivery, integration of content and value to the clinician with broad consensus for uniformly accepted standards and benchmarking across medicine programs (Turney, 2007; Louw et al., 2009; Craig et al., 2010; Tubbs et al., 2014, McBride and Drake, 2018). The heterogeneity in teaching style, mode of delivery and resourcing reported in this study for chiropractic education coupled with the highlighted content gaps related to the anatomical sciences may reflect the need for an agreed and relevant core syllabus in anatomy for chiropractors in Australia. Given that allied health practitioners require a similar skill set as primary contact clinicians, with the hands-on practical approach to treatment, we argue that there exists a similar necessity for all allied health programs.

The lack of inter-program alignment of content related to anatomy education in Australia has been previously identified as a key issue in chiropractic education (Štrkalj et al., 2012a). This lack of alignment has previously been highlighted by others with calls to establish core syllabuses in anatomy internationally (Lisk et al., 2014; Moxham et al., 2014). To this end, establishment of core syllabuses was initiated by the International Federation of Association of Anatomists (IFAA) and the European Federation for Experimental Morphology (EFEM) in 2014 (Moxham et al., 2014) and advocated for regional societies of anatomy to follow suite, as had the Anatomical Society (AS) in United Kingdom, in publishing core anatomy syllabus for medicine (Smith et al., 2016). In addition to the medical syllabus published by the AS, under auspices of the IFAA, several core anatomy syllabuses have been developed and published. These include syllabuses for head and neck anatomy for medical students (Tubbs et al., 2014), and musculoskeletal anatomy for medical students (Webb et al., 2019). Majority of published core syllabuses thus far refer to medical programs (McHanwell et al., 2007; Tubbs et al., 2014; Moxham et al., 2015; Fakoya et al., 2017; Webb et al., 2019), however

recently Connolly et al. (2018) and Finn et al. 2018) published anatomy syllabuses for undergraduate nursing and pharmacy programs respectively. Moxham identified the need for further future developments to also include allied health professions such as chiropractic (Moxham et al., 2014). Considering the small number of chiropractic programs in Australia, a consensus statement outlining anatomy teaching with approval from the accrediting body would be a solid initial contribution.

Limitations of the Study

While this study provides the first analysis of all four of the institutions providing chiropractic qualifications in Australia, it was limited to Australia and could therefore not be compared with other regional trends in chiropractic education. The study however highlights the need for more information on anatomical sciences education in allied health programs which would be able to inform delivery of current evidence based content across programs that is relevant to primary contact musculoskeletal clinicians.

The differences in each university with program infrastructure, along with non-uniform use of terminology relating to divisions/departments, made comparison between institutions sometimes difficult. It was not possible from the data collected to identify why some subjects (for example, histology and embryology) were not included in some anatomy syllabuses, and the impact of omitting of some subject material within a program was not measured against institutions that did include a greater diversity of anatomy related subjects.

CONCLUSION

This study has highlighted the strategic priority of anatomy in chiropractic programs in Australia and provided a description of the course structure, delivery methods, assessment methods, teaching resources, and anatomy academic staff profile in each of the four Australian chiropractic programs. All four institutions reported broadly similar approaches in the delivery of anatomy but with some heterogeneity in content, teaching style, mode of delivery and resourcing. Based on the high number of face-face teaching hours, use of multiple teaching resources and highly qualified teaching staff, it is clear that anatomy is an important foundational discipline as delivered in Australian chiropractic education.

Knowledge of the current state of anatomy education in chiropractic programs is vital to better inform future approaches to anatomy education and will enable comparison to medical and other allied health education programs. There remains a need to formalize a core curriculum for anatomy, together with standards of competency that can be referred to for program evaluation, development and accreditation purposes.

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FIGURE LEGENDS

Figure 1. The contribution of the assessment activities to the final course grade for anatomy units (mean ±SD). Institution 4 did not use "other" assessment activities which include quizzes delivered during tutorial sessions.

Table 1. Australian universities with chiropractic programs, and their recommended degrees for completion

Institution	Recommended / Compulsory first Qualification	Duration of program (years)	Recommended / Compulsory Masters Qualification	Duration of program (years)	Minimum time to total complete (years)
Central Queensland University	Bachelor of Science (Chiropractic)	3	Master of Clinical Chiropractic	2	5
Macquarie University	Bachelor of Chiropractic Science	3	Master of Chiropractic	2	5
Murdoch University	Bachelor of Chiropractic Science	3	Bachelor of Clinical Chiropractic	2	5
Royal Melbourne Institute of Technology	Bachelor of Health Science (Chiropractic)	3	Bachelor of Applied Science (Chiropractic) / Master of Clinical Chiropractic	2	5

Table 2. Anatomy teaching hours in Australian Chiropractic Programs.

Institution	Duration of Course Semester[a] (weeks)	Number of Exclusively Anatomy Courses (n)	Face-to-Face Lectures (hours)	Face-to - Face Practical / Tutorial (hours)	Total Face-to-Face Delivery[b] (hours)	Total Online Delivery (hours)	Total Anatomy (hours)
1	13	4	156	156	312	52	364
2	13	2	104	52	156	0[d]	156
3	12	4	0[c]	48	48	120	168
4	12	3	60	72	132	36	168
Total mean (±SD)	12.5 (±0.6)	3.3 (±1.0)	106.7 (±48.1)	82.0 (±50.4)	162.0 (±110.2)	69.3 (±44.6)	214.0 (±100.2)

[a]Semester is defined as a period (weeks) in the university calendar that courses are offered. Only courses which exclusively deliver anatomy content have been included in the calculation; [b]Total face-to-face delivery for the semester is the sum of the hours of face-to-face lectures and practical/tutorial sessions; [c]Institution 3 did not deliver anatomy content in face-to-face lectures; [d]Institution 2 did not deliver anatomy content online.

Table 3. Delivery of anatomical sciences content

Institution	Topographical (Gross) Anatomy	Histology	Embryology	Neuroanatomy
1	✓	✓	✓	✓
2	✓	NA	NA	✓
3	✓	✓	✓	✓
4	✓	NA	✓	✓

✓indicates that content in that discipline is delivered in the program; NA, content in that discipline is not available/not offered in this institution.

Table 4. Anatomy resources available for student learning

Teaching Resource	Institution 1	Institution 2	Institution 3	Institution 4
Prosected human cadaveric specimens	✓	✓	NA	✓
Plastinated human cadaveric specimens	NA	✓	NA	✓
Anatomical models	✓	✓	✓	✓
3D printed anatomy models	✓	NA	NA	NA
Interactive anatomy software	✓	✓	✓	✓
Digital/electronic atlas	✓	NA	✓	✓
Repository of medical images	✓	NA	✓	NA

✓indicates teaching resource is available/offered in this institution; NA, teaching resource is not available/not offered in this institution

Table 5. Anatomy academics profile

Institution	Permanent staff degrees			Sessional staff degrees			Senior students n (%)	Total n (%)
	PhD n (%)	Masters n (%)	Honours n (%)	PhD n (%)	Masters n (%)	Honours n (%)		
1	2 (10.5)	1 (5.3)[a]	0 (0)	2 (10.5)	14 (73.7)	0 (0)	0 (0)	19 (100)
2	1 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)
3	1 (20.0)	3 (60.0)[a]	0 (0)	0 (0)	1 (20.0)	0 (0)	0 (0)	5 (100)
4	1 (20.0)	0 (0)	0 (0)	2 (40.0)	0 (0)	1 (20.0)	1 (20.0)	5 (100)
Total	5 (16.7)	4 (13.3)	0 (0)	4 (13.3)	15 (50.0)	1 (3.3)	1 (3.3)	30 (100)

Permanent staff refers to staff members on continuous term appointments (equivalent to 'tenure'); Sessional staff refers to staff members on fixed-term appointments; Senior student tutors refers to senior students on limited appointments to assist in delivering face-to-face teaching. [a]Institutions 1 and 3 has one and two Chiropractic academic staff members with Masters level qualifications.