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ASE

Determination of Clinically Relevant Content for a Musculoskeletal Anatomy Curriculum for Physical Medicine and Rehabilitation Residents

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To address the need for more clinical anatomy training in residency education, many postgraduate programs have implemented structured anatomy courses into their curriculum. Consensus often does not exist on specific content and level of detail of the content that should be included in such curricula. This article describes the use of the Delphi method to identify clinically relevant content to incorporate in a musculoskeletal anatomy curriculum for Physical Medicine and Rehabilitation (PM&R) residents. A two round modified Delphi involving PM&R experts was used to establish the curricular content. The anatomical structures and clinical conditions presented to the expert group were compiled using multiple sources: clinical musculoskeletal anatomy cases from the PM&R residency program at the University of Toronto; consultation with PM&R experts; and textbooks. In each round, experts rated the importance of each curricular item to PM&R residency education using a five-point Likert scale. Internal consistency (Cronbach's alpha) was used to determine consensus at the end of each round and agreement scores were used as an outcome measure to determine the content to include in the curriculum. The overall internal consistency in both rounds was 0.99. A total of 37 physiatrists from across Canada participated and the overall response rate over two rounds was 97%. The initial curricular list consisted of 361 items. After the second iteration, the list was reduced by 44%. By using a national consensus method we were able to objectively determine the relevant anatomical structures and clinical musculoskeletal conditions important in daily PM&R practice. Anat Sci Educ 7: 135–143. © 2013 American Association of Anatomists.

Key words: gross anatomy education; graduate curriculum; medical education; educational methodology; clinical anatomy; teaching of anatomy; residency training; musculoskeletal anatomy

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INTRODUCTION

Postgraduate medical education in Canada is guided by the CanMEDS framework "that sets clear and high standards for essential competencies" expected of physician specialists (Frank, 2005). This integrated framework includes the central physician role of the *Medical Expert* which encompasses the ability to "apply knowledge of...fundamental biomedical sciences relevant to the physician's specialty" (Frank, 2005). As such, each specialty has identified specific key and enabling competencies for their discipline including those in the biomedical sciences. Educators have the task of designing and modifying learning experiences to align with these competencies (Irby, 2011).

Traditionally, the fundamental basic sciences are taught during the preclinical years of medical education (Finnerty et al., 2010). In North America, few medical schools have published descriptions of basic sciences courses beyond the first two years of medical training (Spencer et al., 2008). McGill University in Canada was one of the first to publish a description of a basic science curriculum for fourth-year medical students (Patel and Dauphinee, 1984). The purpose of this curriculum after clerkship was to provide students with an opportunity to integrate basic and clinical sciences at a time when they could better appreciate the relevance of basic sciences given their clinical experiences (Patel and Dauphinee, 1984). Only four (24%) Canadian and 24 (19%) US medical schools formally reported a basic science course during the third or fourth year of medical school (Spencer et al., 2008). For educators involved in postgraduate specialties that rely heavily on anatomical knowledge, the lack of basic science education throughout undergraduate medical training is concerning.

Undergraduate anatomy curriculums generally focus on the basic principles common to all areas of medical practice and do not cover the breadth and depth of clinical anatomy knowledge necessary for specialty training (Fitzgerald et al., 2008). In 1999, Cottam surveyed postgraduate residency programs in the United States and found that 57% felt that residents needed a refresher in anatomy and 86% reported that anatomy was either extremely or very important to the mastery of their discipline. Despite its recognized importance, in North America the number of curriculum hours dedicated to anatomy during medical training has substantially declined (Collins et al., 1994; Cottam, 1999; Drake et al., 2009). In addition, research indicates that medical students' and residents' basic science knowledge significantly declines throughout their medical training (Hamilton and Nagy, 1985; Freedman and Bernstein, 1998; D'Eon, 2006; Ling et al., 2008). In 2006, D'Eon from the University of Saskatchewan compared test scores of second-year medical students retaking test questions from three first-year basic science courses (neuroanatomy, physiology and immunology). The results indicate that there was substantial knowledge loss for all three of the basic science courses; however, the most significant knowledge loss (52.7%) was reported in the neuroanatomy course (D'Eon, 2006). In a different study that included basic science questions from the United States Medical Licensing Examination® (USMLE®) Step 1 test on the USMLE Step 2 Clinical Knowledge test found that students' anatomical knowledge declined by 7.9% (Ling et al., 2008). Similarly, Hamilton and Nagy (1985) reported that emergency medicine residents' average test scores on a clinically oriented anatomy exam developed from a first-year medical course was 40% compared to a score of 75% attained by first-year medical students on the same questions. In three separate studies, it has also been shown that the majority (>79%) of medical students and residents fail to demonstrate competency on an examination of fundamental musculoskeletal (MSK) medicine concepts (Freedman and Bernstein, 1998; Matzkin et al., 2005; Queally et al., 2008). In Canada, mandatory MSK education represents only 2.3% of the average medical school curriculum and only 31% of the schools include mandatory exposure to MSK education in a clinical setting (Pinney and Regan, 2001). Combined, these studies suggest that medical graduates entering residency may have a limited working knowledge of important anatomical concepts.

To address this issue, some postgraduate training programs have augmented their curriculum to include structured clinical anatomy training specific to their discipline, and have found it to be successful in improving residents' understanding of anatomical knowledge relevant to their practice (Gordinier et al., 1995; Corton et al., 2003; Barton et al., 2009; Chino et al., 2011). High satisfaction amongst residents has also been reported as an outcome of gross anatomy based curriculum in residency training (Gordinier et al., 1995; Cundiff et al., 2001; Barton et al., 2009; Cabrera et al., 2011; DeFriez et al., 2011). Together these studies demonstrate how structured anatomy courses in postgraduate medical training improve trainees' anatomical knowledge and also subsequently emphasize vertical integration of basic science knowledge with clinical practice.

In Physical Medicine and Rehabilitation (PM&R), the diagnosis and management of MSK conditions and neurological disorders represent the major areas of practice. Thus, an understanding of the clinical anatomy related to these two systems plays an integral role in physiatrists' competence. Surveys of PM&R residents and practicing physiatrists have reported that the number one topic that they would like to learn more about is MSK medicine (Howell et al., 1996; Hart et al., 1999). The identified need for more training in MSK/soft tissue disorders is the result of a perceived deficiency of this topic during residency training (Hart et al., 1999). To date, there have been PM&R education papers published on MSK examination, ultrasound, injection skills and neuromuscular medicine (Smith et al., 2001; Cuccurullo et al., 2004; Button et al., 2007; Finnoff et al., 2010; Lin et al., 2013). Although all of these PM&R educational activities involve an understanding of clinical anatomy none thoroughly address or review the MSK anatomy of the body as a whole.

It appears that there is a need in postgraduate PM&R education for MSK anatomy curricula that address the needs of learners at the postgraduate level. A critical first step in this process is selecting the appropriate content for such a curriculum. Despite differences in the views between basic and clinical science teachers regarding the depth of knowledge to include in a curriculum (Koens et al., 2006), it is not unusual for basic science training to be developed largely by in-house basic science teachers (Bull and Mattick, 2010). Reported methods used to develop content for postgraduate curricula range from small expert group opinion to individual preferences (Chino et al., 2011; DeFriez et al., 2011). In papers describing postgraduate anatomy curricula few report how content was generated for the curriculum. Thus, it is assumed that the individual authors reporting the curriculum determined the content. Based on our literature review, we found no specific papers describing the development of content for a PM&R clinical MSK anatomy curriculum. The scope of this article is to describe the use of the Delphi method to identify clinically relevant content to incorporate in an MSK anatomy curriculum for PM&R residents. The structure of a current PM&R anatomy program will be discussed first to contextualize the framework for which the new curriculum content will be implemented.

DESCRIPTION

University of Toronto PM&R Anatomy Modules

In 2001 the PM&R residency program at the University of Toronto implemented clinical anatomy modules into its training program. Residents do not receive a formal credit for their participation in these sessions; however, attendance is a mandatory component of the program (PGY 1–5, $n = 15–20$). The modules consist of four academic half-day sessions each year, alternating between MSK anatomy and neuroanatomy. Each session is four hours in length and utilizes teaching methodologies that encourage resident participation, such as group discussions, peer teaching, instructor-student teaching, and case presentations. The sessions are lead by a clinical anatomist and at least one PM&R clinical educator.

Prior to the modules, residents are given anatomy and clinical readings to complete along with clinical cases/questions that will be discussed during each session. In the first three hours of each session, residents work in small groups (four residents/group) in the cadaver lab and review anatomical structures using cadaveric prosections. For reference, each lab table has access to a dissection guide and an anatomy atlas. Residents locate anatomical structures on the prosections and a senior resident in each group leads a discussion of related clinical applications. In the last hour, residents work through clinical cases that relate directly to anatomical structures that were reviewed in the cadaver lab. A senior resident prepares and presents the clinical cases to the group and leads the discussion amongst their colleagues. Different residents are in charge of preparing and presenting the clinical cases during each session. The discussion of the clinical cases is interactive and informally takes place in a classroom setting beside the cadaver lab. The clinical anatomist and PM&R clinical educators are present during the entire session and are also involved in enhancing the discussion throughout.

In each MSK session, the emphasis is on the clinical relevance of bones, joints, muscles, and nerves within specific regions. The topics of the MSK sessions are: (1) lumbosacral spine, lumbar/sacral plexus, and gluteal region; (2) lower limb; (3) neck and cervical region, brachial plexus, and superficial and deep back; and (4) upper limb. At this time, no objective evaluation specific to these modules has been completed; however, feedback from many residents indicates that they find these sessions valuable and that their participation in the gross lab is time well spent. However, because of time constraints some topics are covered very quickly or in some cases not covered at all. In addition, the specific content that is covered in each session is sometimes dependent on the present clinical educator's expertise and experience.

The curriculum for the MSK anatomy module has been developed primarily by one clinical anatomist appointed to the Division of Physiatry and one PM&R residency program director. Senior residents are also involved in determining the clinical cases/questions that are discussed in each session. Over the years, refinements have been made to the curriculum content, but to date, no agreement exists on the specific content and level of detail of the content that should be included in the anatomy sessions. Due to time and resource constraints within the PM&R residency program, we seek to determine the most clinically relevant content to incorporate in an MSK anatomy curriculum by using a national consensus method. The Delphi method was chosen as the methodological approach to achieve consensus and it is based on the assumption that "group opinion is considered more valid and reliable than individual opinion" (Keeney et al., 2011).

Delphi Method

The Delphi method is an established approach used in health professions education research for curriculum and competency development (Williams and Webb, 1994; Kilroy and Driscoll, 2006; Flynn and Verma, 2008; Penciner et al., 2011). As Jones and Hunter describe, the Delphi method attempts "to assess the extent of agreement (consensus measurement) and to resolve disagreement (consensus development)" where there is either a lack of scientific evidence or contradictory evidence on a specific topic (Jones and Hunter, 1995). The Delphi method has been shown to be an effective approach to systematically collect experts' opinions and achieve consensus on curricular topics without bias (Williams and Webb, 1994). Additional distinguishing features of the Delphi method are: (1) expert panelists can provide anonymous opinions that are not influenced by peer pressure or other extrinsic factors; (2) expert panelists can be from geographically distinct areas; (3) feedback can be shared in a controlled manner and; (4) the exchange of information can be obtained easily using electronic resources (Stritter et al., 2009; Keeney et al., 2011). Experts for a Delphi are defined by having expert knowledge on the specific topic understudy. To achieve consensus on expert opinion, the Delphi method uses an iterative, multistep process involving a series of questionnaires known as rounds (Jones and Hunter, 1995; Keeney et al., 2011). Typically, in the first round, the expert panel completes open-ended questions on an issue or topic. Responses are then analyzed by the researcher and sent back to the expert panel in the form of statements. In the second round, experts rate their level agreement for each statement on a numerical scale. Again, the researcher analyzes these responses and the statements along with the results from this round are sent back to the expert panel for reconsideration. In the third round, experts have the opportunity to re-rank their agreement for each statement in view of the overall group's response (Jones and Hunter, 1995; Keeney et al., 2011). There is no set rule on the number of rounds that a Delphi should consist of; however, many use two or three rounds (Green et al., 1999). As described by Graham et al. (2003), internal consistency (Cronbach's alpha) is used to determine consensus at the end of each Delphi round. It is reported in the literature that an alpha of 0.7 is satisfactory for research purposes, whereas a minimum alpha of 0.9 is needed for direct clinical applications (Bland and Altman, 1997). Once consensus has been achieved agreement scores are calculated. An agreement score of 80% is reported as a realistic achievement in consensus seeking-methodologies (Green et al., 1999).

Development of Content for a PM&R MSK Anatomy Curriculum

A two round modified Delphi method was used to establish the content for the MSK anatomy curriculum. The modification to the Delphi involved replacing the first round of open-ended questions with a structured questionnaire. This modification is an accepted approach and is often used in Delphi studies (McKenna, 1994). The clinical MSK anatomy curricular items were compiled by the principal investigator (PI) from multiple sources: (1) the current clinical MSK anatomy cases used in the PM&R residency program at the University of Toronto, (2) consultation with five PM&R experts in community and academic practice, and (3) clinical MSK anatomy and PM&R textbooks. Anatomical structures (bones, joints, muscles, nerves) and associated clinical MSK conditions were presented in parallel using an online questionnaire (SurveyMonkey, 2013). The questionnaire was pilot-tested for face

Table 1.

Structure of the Delphi Questionnaire

Anatomical structures	1	2	3	4	5	Clinical MSK correlation	1	2	3	4	5
Deltoid, Teres Major, Rotator cuff muscles	☐	☐	☐	☐	☐	Rotator cuff tendinopathy/tears	☐	☐	☐	☐	☐

An example of how experts were asked to rate each of the proposed curricular items. Instructions: Please rate the importance of understanding the anatomical structures and clinical MSK correlations as core knowledge for PM&R residents using the five-point Likert scale below:

1 Unimportant or not applicable to PM&R residency education.
2 Moderately important to PM&R residency education.
3 Important to PM&R residency education.
4 Very important to PM&R residency education.
5 Essential to PM&R residency education.

and content validity by three physiatrists and one clinical anatomist, and modifications were made to the curricular lists accordingly. The Research Ethics Board at the University of Toronto approved ethics for this study and informed consent was obtained from each participant.

To recruit expert participants this study was presented at the PM&R Royal College specialty committee meeting. The specialty committee consists of PM&R Program Directors ($n = 13$) and physiatrists involved in both community and academic practice ($n = 5$) from across Canada. Following the presentation, an invitation email was sent to all members of the specialty committee. The snowball method (Valente and Pumpuang, 2007) was used to recruit additional expert participants. As such, each specialty committee member who voluntarily agreed to participate was asked to identify two additional PM&R experts and to provide their name and contact information to the PI. The PI then contacted these individuals by email to invite them to participate. An MSK medicine expert in this study was defined as a "physical medicine and rehabilitation medical specialist involved in either academic or community practice in Canada." These individuals were chosen as experts for this study as physiatrists have extensive training in MSK medicine and they are directly involved in the interdisciplinary care of MSK disorders in Canadian practice.

In the first Delphi round, experts were asked demographic information, such as practice location, specific areas of PM&R practice and years of experience as a physiatrist. In addition, each expert was asked to rate the importance of each proposed curricular item ($n = 361$) to PM&R residency education using a five-point Likert scale (Table 1). The five-point Likert scale ranged from 1 (unimportant or not applicable to PM&R residency education) to 5 (essential to PM&R residency education). Experts also had the opportunity to add additional anatomical structures, clinical MSK conditions and comments. At the end of round one, the mean rating and standard deviation for each item was calculated. Internal consistency (Cronbach's alpha) for each subscale and for the overall questionnaire was also calculated. Prior to the study, it was decided that all subscales that reached a Cronbach's alpha ≥ 0.8 after the first iteration would not be included in round two of the Delphi. The remaining subscales, along with the mean and standard deviation for each item within the subscale, were sent back to the experts and they were asked to reconsider their judgments based on the opinions of others using the same five-point Likert scale. In addition, new curricular items suggested in round one were also included in round two. Agreement scores were used as an outcome measure to determine the content to include in the curriculum. The items where $\geq$ 80% of the experts responded 4 or 5 on the Likert scale were recommended to be included in the curriculum.

RESULTS

Demographics

Fifty-seven experts from across Canada were approached to participate in the Delphi questionnaire. A total of 37 physiatrists participated and the overall response rate over two rounds was 97%. Current practice locations for the expert population included: academic-based hospital (73%), community-based hospital (11%) and community practice (24%). Experts represented all subspecialty areas of PM&R practice as described by the American Academy of PM&R except for hospice and palliative medicine, cancer rehabilitation and occupational and environmental medicine (RPCB, 2005). The range of experience as a physiatrist for the expert population was as follows: 1–5 years (37.8%), 6–10 years (10.8%), 10–15 years (18.9%), 15–20 years (13.5%) and greater than 20 years (18.9%).

Curricular Content

The initial list of anatomical structures and clinical MSK conditions consisted of 361 items that were organized into 47 subscales. The overall internal consistency for the first round of the Delphi was 0.99. After the first iteration, 40 of the 47 subscales had a Cronbach's alpha ≥ 0.8 and thus the items in these subscales were not included in round two. The seven subscales that did not reach a Cronbach's alpha ≥ 0.8 included the shoulder complex, scapulothoracic joint, scapulohumeral muscles, distal radio-ulnar and wrist joints, joints of the hand, fascia of the hand and fascia of the leg and foot. The curricular list presented to the expert panel in round two consisted of 45 items, 13 of which were additional items suggested by the expert panel in round one. The overall internal consistency for round two of the Delphi was 0.99.

After the second iteration, agreement scores were calculated. For 208 of the 374 items, at least 80% of experts agreed that the items were either very important or essential to PM&R residency education. These 208 items are

Table 2.

Recommended Items to be Included in a Clinical Musculoskeletal (MSK) Anatomy Curriculum for PM&R Residents

	Anatomical structures	Clinical musculoskeletal conditions
Musculoskeletal anatomy of the upper limb		
Bones of shoulder	Clavicle, scapula, sternum, 1st rib and humerus	Thoracic outlet syndrome
Bones of forearm	Radius, ulna, carpals, metacarpals and phalanges	Fracture of scaphoid/avascular necrosis (AVN); consequences/levels of amputations of the upper limb
Acromioclavicular joint	Ligaments: acromioclavicular and coracoclavicular (conoid and trapezoid)	Dislocation and instability; osteoarthritis
Scapulothoracic joint	Location and movements/arthrokinematics; scapulohumeral rhythm	Types of scapular winging and trapezius winging; suprascapular nerve entrapment; chronic postural strains
Glenohumeral joint	Articular surfaces, movements/arthrokinematics, bursae; ligaments: coracohumeral, transverse humeral, glenohumeral	Dislocation and instability; glenoid labrum tears (SLAP lesion) and adhesive capsulitis; joint injections (landmarks); impingement of the shoulder; osteoarthritis and rheumatoid arthritis; subacromial bursitis/injection sites
Elbow joint	Articulations, movements/arthrokinematics and bursae; ligaments: collateral ligaments (ulnar and radial) and annular	Lateral and medial epicondylitis; subcutaneous olecranon and subtendinous bursitis/injection sites
Distal radio-ulnar joint (DRUJ) and wrist joint	Articular surfaces and movements/arthrokinematics of distal radioulnar joint (DRUJ) and wrist joint; ligaments: radiocarpal ligaments (palmar and dorsal), collateral (ulnar and radial), articular disc of DRUJ (triangular ligament)	Triangular fibrocartilage complex injuries
Joints of hand	Intercarpal, carpometacarpal, metacarpalphalangeal and interphalangeal joints	Skier's thumb/gamekeeper's thumb; osteoarthritis of carpometacarpal (CMC) joint; scapholunate instability; rheumatoid arthritis of the hand
Axioappendicular and scapulohumeral muscles	Anterior and posterior axioappendicular (trunk) muscles; deltoid, teres major, rotator cuff muscles	Myofascial pain associated with upper back and shoulder muscles; rotator cuff tendinopathy/tears
Arm, forearm and hand muscles	Anterior and posterior arm muscles; anterior and posterior forearm muscles; anatomical snuff box; types of palmar grasps/pinches; thenar and hypothenar muscles; lumbricals and interossei (palmar and dorsal)	Bicipital tendonitis and long head of biceps tendon strains; distal biceps tendonitis and rupture; tendonitis of forearm flexors and extensors; DeQuervain's syndrome and compartment syndrome; mallet thumb and Z-deformity; Boutonniere and Swan neck deformity; trigger finger
Fascia of hand		Dupuytren contracture
Nerves of upper limb	Roots, trunks, divisions and cords of brachial plexus; supraclavicular and infraclavicular part of brachial plexus; cutaneous nerves of arm, forearm and hand; dermatomes and myotomes	C5-T1 root impingement and idiopathic brachial neuritis; Erb's palsy; brachial plexopathy; entrapment neuropathies and nerve entrapments; ulnar, radial, and median neuropathies; mechanical vs. infectious/inflammatory radiculopathy and plexopathy

Table 2.
(continued)

	Anatomical structures	Clinical musculoskeletal conditions
Musculoskeletal anatomy of the lower limb		
Bones of hip and thigh	Hip bone, femur and patella; angle of inclination and torsion angle of femur	Ischial bursitis/injection sites; trochanteric bursitis/injection sites
Bones of leg and foot	Tibia, fibula, tarsals, metatarsals and phalanges	Metatarsalgia; plantar spurs; consequences/levels of amputations of the lower limb; pes planus and cavus
Hip joint	Articular surfaces, movements/arthrokinematics and bursae	Hip fractures; osteoarthritis and avascular necrosis (osteonecrosis); subluxation in cerebral palsy; slipped capital femoral epiphysis
Knee joint	Articular surfaces, movements/arthrokinematics and bursae; ligaments: collateral (medial and lateral), oblique popliteal, arcuate popliteal, patellar, cruciate (anterior and posterior) and menisci (medial and lateral); Q angle	Baker's cyst; patello-femoral pain syndrome; genu varum and valga; osteoarthritis and osteochondritis dissecans; tears of anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), lateral collateral ligament (LCL), and menisci; strains and terrible triad; avascular necrosis; patellar tendonitis and instability; injection sites for the knee joint
Ankle joint	Articular surfaces and movements/arthrokinematics; ligaments: talofibular ligament (anterior and posterior), calcaneofibular and medial ligament of ankle	Inversion and eversion ankle injuries
Joints of foot	Subtalar, transverse tarsal, cuneonavicular, tarsometatarsal, intermetatarsal, metatarsophalangeal and interphalangeal joints; Ligaments: spring, long plantar and short plantar; longitudinal and transverse arches of the foot	Hallux limitus, rigidus, valgus; Charcot arthropathy; osteoarthritis; gout
Gluteal, thigh, leg and foot muscles	Superficial and deep gluteal muscles; anterior, medial and posterior thigh muscles; Pes anserinus; anterior, lateral and posterior leg muscles; muscles on the dorsum of the foot	Myofascial pain associated with gluteal muscles; piriformis syndrome; Trendelenberg sign and gait; gluteus medius bursitis/injection sites; snapping hip; hip flexor contractures; tibialis; posterior tendon insufficiency/rupture; medial tibial stress syndrome and compartment syndrome; Achilles and fibular (peroneal) tendinitis
Fascia of leg and foot	Flexor/extensor/fibular retinaculum and plantar fascia	Plantar fasciitis
Nerves of lower limb	Roots to lumbar and sacral plexus and lumbosacral trunk; nerves to gluteal region, thigh, leg and foot; cutaneous nerves of the buttocks, thigh (including inguinal region), leg and foot; dermatomes and myotomes	Bowel/bladder and sexual dysfunction; lumbosacral plexopathy; entrapment neuropathies; neuropathies: sciatic, obturator, femoral, tibial, common fibular (peroneal); meralgia paresthetica; diabetic amyotrophy/neuropathy; Morton's neuroma
Musculoskeletal anatomy of the neck and cervical spine		
Bones of neck and cervical spine	C1-C7 and hyoid	Stingers and burners; mechanical cervical spine pain

Table 2.
(continued)

	Anatomical structures	Clinical musculoskeletal conditions
Atlanto-occipital joint	Articular surfaces and movements/ arthrokinematics	
Atlanto-axial joint		Atlanto-axial instability
Cervical vertebrae	Articular surfaces, movements/arthrokinematics and intervertebral discs; ligaments of the cervical spine; vertebral artery	Cervical disc herniations; hyperextension injury; cervical spondylosis including central and foramina stenosis; cervical facet syndrome
Neck and suboccipital muscles	Sternocleidomastoid; prevertebral muscles	Myofascial pain associated with the head and neck muscles; whiplash injury and neck spasms
Nerves of neck	C1–C8 spinal nerves; dermatomes and myotomes	Radiculopathy and plexopathy; greater occipital nerve blocks and occipital neuralgias
Clinical musculoskeletal anatomy of the trunk		
Bones of trunk	T1–L5, sacrum, coccyx and thoracic cage (ribs and sternum)	Scoliosis, excessive kyphosis and lordosis; mechanical thoracic spine pain; compression and stress fractures of vertebra; spina bifida
Joints of thoracic and lumbar vertebrae	Articular surfaces, movements/arthrokinematics and intervertebral discs; ligaments associated with the thoracic and lumbar spine	Lumbosacral facet joint syndrome/ osteoarthritis of facets; degenerative disc disease (DDD) and disc herniations; spondylolisthesis and spondylosis of thoracic and lumbar spine; stenosis
Sacro-iliac joint	Articular surfaces and movements/ arthrokinematics	Sacroiliac joint dysfunction and sacroiliitis
Nerves of trunk	Spinal nerves (T1-S4); dermatomes and myotomes of trunk (thorax and abdomen)	

Note: All individual muscles were included in the questionnaire, but for brevity only muscle groups are listed. Attachments, actions, and innervation for all muscles within the muscle groups listed should be discussed.

recommended for inclusion in a clinical MSK anatomy curriculum for PM&R residency training (Table 2).

DISCUSSION

The modified Delphi method is an effective process to develop content for a clinical MSK anatomy curriculum for PM&R residents. The top-down approach using physiatrists in practice from across the country resulted in the identification of 208 relevant anatomical structures and clinical MSK conditions important in Canadian PM&R practice. This represents a 44% reduction of the initial curricular items. Consensus on the items to include in the curriculum was reached without the expert participants ever having to meet in person, and on average, it took each participant 68 min to complete both Delphi rounds. It is important to note that this average time is likely above the actual time it took, as some participants opened the questionnaire and then returned hours later to complete it. Some argue that the Delphi method requires too much investment of clinicians' time; however, based on our experience an approximate investment of 68 min and a high response rate (97%) does not support this argument.

The face-to-face introduction of this study at the Royal College PM&R specialty committee meeting was a successful way to engage those with a vested interest in postgraduate PM&R medical education. Similar to Penciner et al. (2011), the use of the snowball technique enabled us to recruit and maintain expert participants from across the country for the Delphi process. The use of this technique resulted in the participation of 37 physiatrists representing a range of years of experience and also a high response rate of 97% over two rounds, both of which enhance the validity of this study. Other studies that have used the Delphi method for competency and curriculum development have reported the involvement of 10–31 experts to establish consensus (Turner et al., 2002; Kilroy and Driscoll, 2006; Flynn and Verma, 2008; Penciner et al., 2011). Thus, the participation of 37 physiatrists in this study represents an above-average sample size.

When designing training programs it is imperative that content included in the curriculum is relevant to daily clinical practice (Ahmed et al., 2010). The process of developing content for postgraduate anatomy curricula is not commonly described in the literature. Reported methods that have been mentioned for determining content for postgraduate anatomy curricula include individual preferences (Gordinier et al., 1995; Chino et al., 2011;) and small convenience samples (Corton et al., 2003; Barton et al., 2009; DeFriez et al., 2011). In the United States some PM&R educational activities have reported using guidelines established by educational committees, departments' billing data and informal surveys to establish content (Smith et al., 2001; Cuccurullo et al., 2004; Button et al., 2007; Lin et al., 2013). Although there are focused efforts on postgraduate PM&R education in Canada there are no established guidelines for PM&R anatomy education. Although developing content for curricula can be a complex task (Prideaux, 2007), we found the Delphi method to be a straightforward process in establishing relevant and necessary curricular content. In addition, the use of the Delphi method allowed for representation of physiatrists from across the country, and thus, the content for the curriculum reflects clinical practice of physiatrists nationally and not within a limited region. In comparison to other PM&R education activities (Smith et al., 2001; Cuccurullo et al., 2004; Button et al., 2007; Finnoff et al., 2010; Lin et al., 2013), this is the first comprehensive description of content for a MSK anatomy curriculum for PM&R residents.

This study also had limitations that should be noted. Similar to other Delphi studies, the items included in the modified Delphi may be biased since they were predetermined by the PI. To minimize this bias, the PI did consult with physiatrists in both academic and community practice along with clinical anatomy and PM&R textbooks to obtain additional items for the initial curricular lists. The participants were also able to suggest additional curricular items in the first round of the Delphi. A selection bias may also exist in this study since 20 of the 57 physiatrists approached to complete the questionnaire did not participate. The authors do not believe this to be too concerning since the experts that did participate represented almost all subspecialty areas of PM&R practice as described by the American Academy of PM&R.

CONCLUSION

This research supports using evidenced-based content in postgraduate anatomy curricula. The results clearly define the key anatomical concepts that have an essential application to PM&R practice. The identified content will be organized and implemented into the existing MSK anatomy sessions in the PM&R training program at the University of Toronto. The authors acknowledge that establishing clinically relevant content is only one component of curriculum development process (Kern, 2009). Once the new curricular content has been implemented, its effectiveness will be tested. It seems reasonable to assume that a reduction (44%) of content will allow for more time to be spent on vertically integrating relevant anatomical concepts and clinical conditions important in the practice of physiatry.

This MSK anatomy content will be shared with all PM&R residency programs across the country to standardize MSK anatomy education for PM&R residents. The established content will also be used to develop a list of core competencies relevant to MSK anatomy that can be used to guide the development of and preparation for clinical examinations. The content of this MSK anatomy curriculum may also be useful to overlapping medical specialties (rheumatology, orthopedics, plastics, emergency medicine, family medicine, and sports medicine). Finally, the Delphi methodology employed in this study serves as a guideline for the development of future evidence-based clinical anatomy content for postgraduate residency training. Future research will explore how to effectively deliver and assess the effectiveness of this clinical anatomy curriculum to postgraduate trainees.

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