Distribution Statement

Distribution A: Public Release.

The views presented here are those of the author and are not to be construed as official or reflecting the views of the Uniformed Services University of the Health Sciences, the Department of Defense or the U.S. Government.

Representation and Quality of Physical Medicine and Rehabilitation Clerkships in US Medical Schools

By

Danny Benbassat, PhD

Thesis submitted to the Faculty of the
Health Professions Education Graduate Program
Uniformed Services University of the Health Sciences
In partial fulfillment of the requirements for the degree of
Master of Health Professions Education 2020

UNIFORMED SERVICES UNIVERSITY OF THE HEALTH SCIENCES
DEPARTMENT OF MEDICINE
4301 JONES BRIDGE ROAD
BETHESDA, MARYLAND 20814-4799
www.usuhs.edu

July 13, 2020

APPROVAL SHEET

Title of Thesis: Representation and Quality of Physical Medicine and Rehabilitation Clerkships in US Medical Schools

Name of Candidate: Danny Benbassat, PhD

07/13/2020

THESIS AND ABSTRACT APPROVED:

DATE:

[redacted]

7/13/2020

Lauren Maggio, PhD
DEPARTMENT OF MEDICINE
Committee Chairperson

[redacted]

07/13/2020

Abigail Konopasky, PhD
DEPARTMENT OF MEDICINE
Thesis Advisor

CERVERO.RONALD.MICHAEL.1536777721 Digitally signed by CERVERO.RONALD.MICHAEL.1536777721 Date: 2020.07.13 16:10:43 -04'00'

Ronald M. Cervero, PhD
DEPARTMENT OF MEDICINE
Thesis Advisor

ACKNOWLEDGMENTS

My heartfelt gratitude to my incredibly supportive and sage research mentors Dr. Ronald Cervero and Dr. Abigail Konopasky. I would also like to extend my gratitude to my awesome academic advisor, Dr. Holly Meyer, for helping me navigate the ins and outs of the curriculum. Lastly, a shout out to my practicum preceptors, Dr. Dina Kurzweil, Dr. Holly Meyer, and Dr. Anita Samuel, as well as my course instructors, for making the HPE program one of the best in the country.

The author hereby certifies that the use of any copyrighted material in the thesis manuscript entitled:

"Quantity and Quality of Physical Medicine and Rehabilitation Clerkships in US Medical Schools"

is appropriately acknowledged and, beyond brief excerpts, is with the permission of the copyright owner.

Danny Benbassat
Department of Physical Medicine & Rehabilitation
Uniformed Services University
Date: 3/25/2021

BENBASSAT.DANNY.1497030486

Digitally signed by BENBASSAT.DANNY.1497030486
Date: 2021.03.29 20:34:20 -04'00'

DISCLAIMER

The views presented here are those of the author and are not to be construed as official or reflecting the views of the Uniformed Services University of the Health Sciences, the Department of Defense or the U.S. Government

ABSTRACT

Representation and Quality of Physical Medicine and Rehabilitation Clerkships in US Medical Schools

Danny Benbassat, Master of Health Professions Education, 2020

Thesis directed by: Ronald M. Cervero, PhD, and Abigail Konopasky, PhD, Center for Health Professions Education, Uniformed Services University.

Purpose: Prior studies found that medical schools failed to expose undergraduate students to clinical musculoskeletal medicine. The purpose of this study was to focus on physical medicine and rehabilitation (PM&R) and add a quality assessment component.

Methods: A multi-methods design was used to evaluate 154 medical schools in the U.S. Representation (availability) of required, selective, and elective clerkships was assessed using measures of central tendencies. Quality of clerkships was assessed by comparing clerkship curricula to a criterion standard developed by the authors.

Results: Few medical schools required a musculoskeletal (4%) or PM&R (2%) clerkship. Few schools (7%) also required PM&R sub-specialty clerkships. Some schools offered musculoskeletal medicine (15%), and few offered PM&R sub-specialty (8%) or PM&R (2%), selective clerkships. Combined with elective clerkships, most medical schools offered at least one musculoskeletal medicine (97%) or PM&R/PM&R sub-specialty (93%) clerkship. In terms of quality, only half of the criterion standard objectives were assessed by PM&R clerkships.

Bioethics and geriatric rehabilitation were disproportionately assessed in required clerkships and therapeutic & diagnostic injections objectives were disproportionately assessed in elective clerkships. Lastly, using thematic analysis, 22 objectives were added to the original criterion standard.

Conclusions: Medical schools continued to exclude PM&R, and musculoskeletal medicine, from the list of required clerkships. In fact, we found a surprising downtrend in representation compared to earlier studies. Evidence suggests that these clerkships are underemphasized, not underrepresented, in undergraduate curricula. In addition, the lack of consistent and comprehensive use of objectives may be indicative of a problem with the quality of existing clerkships. As a solution, we propose a comprehensive list of learning objectives for undergraduate PM&R clerkships based on a criterion standard and empirical data. This groundbreaking list will help medical schools meet the need for physicians that are able to treat and manage polytrauma injuries. These musculoskeletal and psychological injuries are common in the growing geriatric civilian healthcare and in the military healthcare systems. Military physiatrists are able to stabilize and offer aggressive medical intensive care on the battlefield during wartime and to care for warriors and beneficiaries, including pediatric and geriatric, during peacetime.

Key Words: Physical medicine and rehabilitation, musculoskeletal medicine, undergraduate medical clerkships.

TABLE OF CONTENTS

List of Tables

Chapter 1 - Introduction

Physical Medicine and Rehabilitation (PM&R) is a relatively new subspecialty in medicine that "emphasizes the prevention, diagnosis, treatment and rehabilitation of people disabled by disease, disorder or injury".[1] Physicians that specialize in PM&R are known as physiatrists and focus on functional independence and quality of life for patients with nervous and musculoskeletal injuries. Unlike other medical specialists that focus on an organ system or systems, physiatrists address the functioning of the whole patient, including physical, emotional, medical, vocational, and social needs.[1] According to the Association of Academic Physiatrists, there is a growing need for physiatrists due to a growing number of individuals with a disability, an aging population, older retirement age, and shortage of physiatrists in certain areas and sub-acute rehabilitation settings such as skilled nursing facilities.[1] The 2019 Medscape Physician Compensation Report, the most comprehensive and widely used physician salary survey in the United States, reported that physiatry salary is on the rise as more baby boomers become senior citizens and require more specialized medical services.[2]

This growing specialization presents unique contributions for civilian and military medicine alike. For example, in the civilian population there is a growing need for physiatrists due to an increasing number of individuals with disability, an aging population, older retirement age, and a shortage of physiatrists in certain areas and sub-acute rehabilitation settings such as skilled nursing facilities.[1,3] In fact, musculoskeletal disorders (low-back and neck pain, osteoarthritis, rheumatoid arthritis, gout, and other musculoskeletal conditions) are the leading cause of disability in the U.S. and, after age 40, the leading cause of years lived with disability.[4] These debilitating conditions and the direct and indirect expenditures associated with them, create a notable burden on the US economy.[5]

Similarly, terrorist attacks and insurgent activities, that do not discriminate soldier from civilian, present a burden on the military and civilian health systems alike.[6,7,8] In fact, more civilians suffered from blast exposure trauma than soldiers in the Iraq and Afghanistan wars.[9] The exposure of civilians to explosive devices in theater, and at the home front, continues to be a significant concern. Unlike soldiers, civilians are not protected by armor and include pediatric and geriatric populations. Lessons-learned from 93 mass-causality terrorist attacks in Israel suggest that civilian hospitals may be ill-equipped to deal with the polytrauma nature of blast injuries. The combination of head and chest injuries, for example, presents a challenge because clinical guidelines for traumatic brain injury and for lung injury may be contradictory.[10]

Treatment of these devastating musculoskeletal and psychological injuries requires integration of medical, surgical, and behavioral health, as well as expertise in neuromuscular medicine, trauma medicine, brain injury, spinal cord injury, musculoskeletal medicine and imaging, orthopedics, pain management, and rehabilitation medicine. Due to their training, physiatrists are able to provide such multidisciplinary care in order to restore patients to productive lives. They are also able to assist in other, non-rehabilitative, duties such as triage or trauma life support.[8,11,12] Lastly, civilian and military physiatrists are also trained to provide care in rheumatology, sports medicine, palliative medicine, and rehabilitation medicine.[6,8]

Despite the growing need for physiatrists, there is evidence that pre-clinical medical students' knowledge of physiatry is poor. In the United States, researchers found that pre-clinical medical students at Brown University had a limited knowledge of physiatry as a specialty.[13] A study conducted in Hungarian, Polish, and Croatian medical schools found that medical students had low knowledge of physiatry among all studied groups.[14] A cross-sectional study of 175 medical students at Isfahan University of Medical Sciences in Iran found that the level of

knowledge about physiatry and its role in the diagnosis and treatment of musculoskeletal system problems was weak.[15] In Poland, a study that evaluated basic knowledge of 214 medical students found that the students had poor knowledge of physiatry's role in the health care system.[3] In response, researchers examined ways to increase awareness and knowledge of physiatry. As expected, researchers proposed exposure to physiatry as a solution. One study found notable results from a single-day physiatry career fair.[4] However, a body of work suggests that a 2-week[5] clerkship is the most effective solution.[6,7,8,9]

If a clerkships increase specialty knowledge, but knowledge of physiatry is poor, it is logical to conclude that PM&R clerkships are likely underrepresented in undergraduate medical education. This conclusion was supported in what was, perhaps, the first published study that attempted to assess the representation and duration of musculoskeletal instruction in US medical schools. This 2003 study by DiCaprio and colleagues[10] was replicated by Bernstein and colleagues[11] in 2011 and by DiGiovanni and colleagues[12] in 2014. Although there was a notable increase in the number of schools that offered a distinct preclinical course in musculoskeletal medicine, PM&R clerkships continued to be underrepresented in undergraduate clinical medical school curricula. At first glance, the increase in preclinical courses seems encouraging. However, without clinical experience, classroom education confers little advantage to medical student knowledge and competency.[16] Some authors have suggested that the continued lack of clinical experience may contribute to poor musculoskeletal medicine knowledge, performance, and confidence, as well as an overall decrease in the quality of patient care.[10,12] It is unclear if the increase in awareness and undergraduate medical programs led to more PM&R clerkships in US medical schools since 2014.

Theoretical Framework

Our work is grounded in the six-step approach to curriculum development. Kern developed this approach from generic approaches that advocated linking curricula to health care needs.[17] He based this approach on four underlying assumptions: (a) Educational programs are based on aims or goals, (b) educators have a professional and ethical obligation to meet learner needs, (c) educators should be accountable for the outcomes of their curricula, and (d) a systematic approach to curriculum development will help educators develop program goals, meet their obligations, and be accountable to their learners. As shown in Table A below, Kern suggests that the development of specific and measurable goals and objectives (step 3) drive and enable the design of effective educational strategies, implementation of a curriculum, and the evaluation of training or program. Thus, we suggest that the design, implementation, and evaluation of effective clinical clerkships depend on the creation of measurable objectives.

Table A. Six-step approach to curriculum development

Step	Description
1. Problem identification/general needs assessment	A general needs assessment is defined as the difference between the current approach and an ideal approach to addressing a need(s).
2. Targeted needs assessment	This step tailors the general needs assessment to a specific, or targeted, group of learners and the learning environment (e.g., geriatric).

3. Goals and Objectives	**Whereas goals are general desired outcomes (e.g., restful sleep), objectives are measurable specific outcomes (e.g., 7-8 hours of uninterrupted sleep per night).**
4. Educational Strategies	In this step, strategies (content and methods) are chosen to achieve the goals and specific objectives.
5. Implementation	In this step the curriculum is methodically implemented and refined.
6. Evaluation and Feedback	In the final step, the impact of the curriculum on the individual and the program is assessed and evaluated.

Whereas prior studies focused on the quantitative (number and duration) aspects of musculoskeletal curricula in medical schools, attempts to study the qualitative aspects are lacking. Although there have been attempts to propose goals and objectives for undergraduate musculoskeletal education, these goals and objectives were developed using different methodologies and written with different levels of specificity.[18] Therefore, any attempt to compare curricular effectiveness among programs is futile. In addition, whereas prior studies focused on undergraduate musculoskeletal education in general, no studies focused on the quality of PM&R curricula in particular. Therefore, it is unknown if the quality of existing PM&R clerkships is adequate.

Academic Relevance

Kern based his Six-Step Approach to Curriculum Development[17] on four basic assumptions. First, educational programs have aims or goals. Second, educational programs have an ethical obligation to address and meet the needs of their learners and society at large. Third, educational programs are accountable for the consequences of their curricula. Finally, to be effective, curriculum development must be based on a logical and systematic process.

Thus, medical schools have the professional and ethical obligation to meet the growing need for physiatrists in the civilian and military health systems. In addition, they should be held accountable for the representation and quality of PM&R clerkships in their institution. Failure to do so will fail to expose students to the unique benefits of this comprehensive and versatile specialty.

Study Purpose

The purpose of this study is to investigate the representation and quality of PM&R clerkships in U.S. medical schools. We operationalize these terms as:

Clinical representation of PM&R medicine: Number and duration of required, selective, and elective PM&R clerkships.

Quality of PM&R medicine: Adherence of PM&R clerkship curricula to a criterion standard developed for the purpose of this study.

Research Questions

- Research Question 1a: Has representation of clinical PM&R clerkships in undergraduate medical education changed since 2014-2015?
- Research Question 1b: How does representation of PM&R clerkships compare with other specialties?

- Research Question 1c: Has representation of clinical musculoskeletal clerkships in undergraduate medical education changed since 2014-2015?
- Research Question 2: What is the quality of existing PM&R clerkships?

References

1. Association of Academic Physiatrists. What is Physiatry? An Overview website. https://www.physiatry.org/page/WhatIsPhysiatry. Accessed June 19, 2019
2. Kane L. Medscape. Medscape Physiatrist Compensation Report 2019 website. https://www.medscape.com/slideshow/2019-compensation-physiatrist-6011344#2. Accessed July 20, 2019
3. Tederko P, Krasuski M, Nyka I, Denes Z. Knowledge of physical and rehabilitation medicine among physicians and medical students in Poland. *Wiadomosci lekarskie* (Warsaw, Poland: 1960). 2015;68:123.
4. Brane LB, Carson R, Susmarski AJ, Lewno AJ, Dicianno BE. Changing Perception: Outcomes from a Physical Medicine and Rehabilitation Medical Student Interest Fair. *American Journal of Physical Medicine & Rehabilitation*. 2017;96:362-365.
5. Lalka A, Caldwell R, Black A, Scott FA. An Evaluation of the Effectiveness of a Medical School Musculoskeletal Curriculum at an Academic Medical Center. Higher Learning Research Communications. 2018;8:55-63.
6. Tham SL, Kong KH. Impact of a week-long rehabilitation medicine posting on third-year medical students' rehabilitation knowledge and attitudes. *Annals of Physical and Rehabilitation Medicine*. 2018;61:e524-e525.
7. DiGiovanni B, Southgate R, Mooney C, Chu J, Lambert D, O'Keefe R. Factors impacting musculoskeletal knowledge and clinical confidence in graduating medical students.

Journal of Bone and Joint Surgery-American Volume. 2014;96A:e185-1-7.

8. Faulk C, Mali J, Mendoza P, Musick D, Sembrano R. Impact of a required fourth-year medical student rotation in physical medicine and rehabilitation. *American Journal of Physical Medicine & Rehabilitation*. 2012;91:442-448.
9. Kirshblum SC, Delisa JA, Campagnolo DL. Mandatory clerkship in physical medicine and rehabilitation: Effect on medical students' knowledge of physiatry. *Archives of Physical Medicine and Rehabilitation*. 1998;79:10-13.
10. DiCaprio M, Covey A, Bernstein J. Curricular requirements for musculoskeletal medicine in American medical schools. *Journal of Bone and Joint Surgery-American Volume*. 2003;85A:565-567.
11. Bernstein J, Garcia G, Guevara J, Mitchell G. Progress report: The prevalence of required medical school instruction in musculoskeletal medicine at decade's end. *Clinical Orthopaedics and Related Research*. 2011;469:895-897.
12. DiGiovanni BF, Sundem LT, Southgate RD, Lambert DR. Musculoskeletal medicine is underrepresented in the American medical school clinical curriculum. *Clinical Orthopaedics and Related Research*. 2016;474(4):901-907.
13. Le B, Parziale JR. Pre-clinical Medical Students' Attitudes Toward Physical Medicine and Rehabilitation. *Rhode Island medical journal*. 2019;102:26.
14. Tederko P, Krasuski M, Denes Z, Moslavac S, Likarevic I. What medical doctors and medical students know about physical medicine and rehabilitation: a survey from Central Europe. *European Journal of Physical and Rehabilitation Medicine*. 2016;52:597-605.
15. Khosrawi S, Ramezanian H, Mollabashi R. Survey of medical students' attitude and knowledge toward physical medicine and rehabilitation in Isfahan University of Medical

Sciences. *Journal of Education and Health Promotion*. 2018;7:51-51.

16. Khorsand D, Khwaja A, Schmale G. Early musculoskeletal classroom education confers little advantage to medical student knowledge and competency in the absence of clinical experiences: a retrospective comparison study. *BMC Medical Education*. 2018;18:46-46.
17. Kern KE. A six-step approach to curriculum development. In: Thomas PA, Kern DE, Hughes MT, Chen BY, eds., *Curriculum Development for Medical Education*. 3rd ed. Baltimore, MD: John Hopkins University Press; 2016.
18. Monrad SU, Zeller JL, Craig CL, DiPonio LA. Musculoskeletal education in US medical schools: lessons from the past and suggestions for the future. *Current Reviews in Musculoskeletal Medicine*. 2011;4:91-98.

Chapter 2 – Research Publication

Representation and Quality of Physical Medicine and Rehabilitation Clerkships in US Medical Schools

This chapter's content was submitted for publication to the *American Journal of Physical Medicine & Rehabilitation* on 20 June 2020.

Author Information: Danny Benbassat, PhD,[a] Ronald Cervero, PhD,[b] Matthew E. Miller, MD,[c] Nelson Hager, MD,[a] Abigail Konopasky, PhD[b]

[a] Department of Physical Medicine and Rehabilitation, School of Medicine, Uniformed Services University of the Health Sciences, Bethesda, MD

[b] Center for Health Professions Education, School of Medicine, Uniformed Services University of the Health Sciences, Bethesda, MD

[c] National Capital Consortium Physical Medicine and Rehabilitation Residency Program, Walter Reed National Military Medical Center, Bethesda, MD

Acknowledgements: The authors would like to thank the medical schools that made their curricula easily accessible online. Special gratitude is also extended to the programs that responded to the request for information amidst the COVID-19 pandemic.

Funding/Support: None.

Disclosures: The authors declare no conflicts of interest. The authors further declares that the research, manuscript, or abstract have not been previously presented.

Ethical Approval: None.

Disclaimer: The opinions and assertions expressed herein are those of the authors and do not necessarily reflect the official policy or position of the Uniformed Services University or the Department of Defense.

Representation and Quality of Physical Medicine and Rehabilitation Clerkships in US Medical Schools

Objective: Prior studies found that medical schools failed to expose undergraduate students to clinical musculoskeletal medicine. The objective of this study was to focus on physical medicine and rehabilitation (PM&R) and add a quality assessment component.

Design: A multi-methods design was used to evaluate 154 US medical schools. Representation of clerkships was assessed using measures of central tendencies. Quality was assessed by comparing clerkship curricula to a criterion standard and using an emergent design.

Results: Representation. Whereas few medical schools required a musculoskeletal (4%) or PM&R (2%) clerkship, most offered optional rotations in musculoskeletal (97%) or PM&R/PM&R sub-specialty (93%). Quality. Combined, most schools assessed 6 of 12 criterion objectives, but variations were noted among required and optional clerkships. Analysis of data resulted in the emergence of 22 additional objectives.

Conclusions: Medical schools continued to exclude PM&R, and musculoskeletal medicine, from the list of required clerkships. In fact, a surprising downtrend in representation was found. However, evidence suggests that these clerkships are underemphasized, not underrepresented. Furthermore, the lack of consistent and comprehensive use of objectives may be indicative of a problem with the quality of existing clerkships. As a solution, this paper presents a comprehensive list of learning objectives for undergraduate PM&R clerkships based on a criterion standard and empirical data.

Key Words: Physical medicine and rehabilitation, musculoskeletal medicine, undergraduate medical clerkships

Summary Text

What is Known.

Prior studies found that clinical musculoskeletal medicine is underrepresented in US medical school curriculum.

What is New.

This study focuses on PM&R and adds a quality assessment of existing clerkships. Of AAMC-member schools, 10% offered required and 94% offered elective PM&R, or PM&R sub-specialty, clerkships. Hence, evidence suggests that PM&R clerkships are underemphasized, not underrepresented. Also, PM&R clerkships only used 6 of 12 criterion standard objectives. This may represent a problem with the quality of existing clerkships. In order to meet the growing need for physiatrists, this study concludes with practical recommendations and a groundbreaking list of objectives for undergraduate clerkships.

Introduction

Physical Medicine and Rehabilitation (PM&R) is a relatively new specialization in medicine that "emphasizes the prevention, diagnosis, treatment and rehabilitation of people disabled by disease, disorder or injury".[1] Like the other rehabilitative professions such as physical therapy and occupational therapy, PM&R grew from the rehabilitative needs of soldiers in World War I and World War II.[2,3] Physicians that specialize in PM&R are known as physiatrists and focus on functional independence and quality of life for patients with a wide variety of medical conditions affecting the brain, spinal cord, nerves, bones, joints, ligaments, muscles, and tendons.

This growing specialization presents unique contributions for civilian[1] and military[3] medicine alike. Physiatrists are trained to treat polytrauma musculoskeletal and psychological injuries that require integration of medical, surgical, and behavioral health. They provide coordinated care to patients with complicated medical and physical needs due to their expertise in brain injury, musculoskeletal medicine and imaging, neuromuscular medicine, orthopedics, pain management, palliative medicine, rehabilitation medicine, rheumatology, spinal cord injury, sports medicine, and trauma medicine. Thus, physiatrists are in a unique position to provide multidisciplinary care to restore patients to productive lives and assist in other, non-rehabilitative, duties such as triage or trauma life support.[3]

Despite the crucial role that physiatrists play in the civilian and military health care systems, there is evidence that medical schools, across the globe, fail to adequately introduce medical students to the specialty of PM&R. In the US, researchers found that pre-clinical medical students at Brown University had a limited knowledge of physiatry as a specialty.[4] A study conducted in Hungarian, Polish, and Croatian medical schools found that medical students

had low knowledge of physiatry among all studied groups.[5] A cross-sectional study of 175 medical students at Isfahan University of Medical Sciences in Iran found that the level of knowledge about physiatry and its role in the diagnosis and treatment of musculoskeletal system problems was weak.[6] Lastly, in Poland, a study that evaluated basic knowledge of 214 medical students found that the students had poor knowledge of physiatry's role in the health care system.[7]

In 2003, DiCaprio et al. found that musculoskeletal clerkships are underrepresented in undergraduate medical education.[8] This finding was replicated in 2011[9] and 2016.[10] As shown in the summary table (Supplemental Table 1), despite a notable increase in the number of schools that offered a distinct preclinical course in musculoskeletal medicine, musculoskeletal clerkships continued to be underrepresented. At first glance, the increase in preclinical courses seems encouraging. However, without clinical experience, classroom education confers little advantage to medical student knowledge and competency.[11] Some authors have suggested that the continued lack of clinical experience may contribute to poor musculoskeletal medicine knowledge, performance, and confidence, as well as an overall decrease in the quality of patient care.[8,10]

This lack of clinical representation is at odds with studies on the impact of clerkships worldwide. In the US, fourth-year medical students at the Kessler Institute for Rehabilitation were exposed to a two-week mandatory PM&R clerkship. The mandatory clerkship increased awareness of the practice and benefits of PM&R services.[12] At the Brody School of Medicine, in East Carolina University, fourth-year medical students were exposed to a required two-week neuromuscular and musculoskeletal rehabilitation rotation. This fourth-year clerkship increased knowledge of PM&R.[13] At the University of Rochester School of Medicine and Dentistry

participation in a musculoskeletal elective experience was the only factor that led to a significant increase in musculoskeletal knowledge.[14] Lastly, in Singapore, 72 third-year medical students that were exposed to a PM&R clerkship improved in pre- and post-clerkship knowledge and awareness of PM&R.[15] Without such clinical training, medical students may not recognize that physiatrists are in a unique position to provide general primary care and subspecialty care, making them "an excellent force multiplier"[16(p188)] in the health system.

Whereas prior studies focused on the quantitative (number and duration) aspects of musculoskeletal curricula in medical schools, attempts to assess the quality of these curricula are lacking. Although there have been attempts to propose goals and objectives for undergraduate musculoskeletal education, these goals and objectives were developed using different methodologies and written with different levels of specificity.[17] This inconsistency renders futile any attempt to compare curricular effectiveness among programs. Therefore, it is unknown if the quality of existing musculoskeletal clerkships in general, and PM&R clerkships in particular, are adequate.

Hence, the objectives of this study are to (a) assess trends in the representativeness of PM&R clerkships, (b) propose a method and assess the quality of PM&R clerkships, and (c) assess trends in the representativeness of musculoskeletal clerkships.

Methods

This study was conducted from August 2019 to May 2020. The research team consisted of three social science researchers and two physiatrists. Both physiatrists were board-certified and practiced at the Walter Reed National Military Medical Center in Bethesda MD. As shown in Supplemental Figure 1, a multi-methods design was used to assess the representativeness and

quality of clerkships. An internal review board or consent forms were not used since this study used publicly available data without human participants.

Clinical Representativeness Assessment.

The Association for American Medical Colleges (AAMC) directory[18] was used to obtain a list of accredited US medical schools. This list was used to find the frequency and duration (in weeks) of required clerkships for each medical program. It was also used to find the frequency and duration of selective and elective musculoskeletal and PM&R clerkships. Data were obtained directly from university web sites (to include catalogs, bulletins, and departments), Online Access to Student Information and Scheduling search engine, and Visiting Student Application Service search engine. In terms of time frame, the latest available data was used. For example, if a program required 8.0 hours for a 2020, but 6.0 hours for a 2022, graduating class, 6.0 hours was recorded. Programs were contacted directly if information was not available online (n = 6), but most (n = 5) did not respond. In addition, information was missing for universities that did not matriculate a class by 2019 (n = 5). This resulted in a final sample size of 154 medical schools for the required and selective clerkship analysis and 144 schools for the elective analysis. Musculoskeletal electives consisted of musculoskeletal medicine, musculoskeletal radiology, musculoskeletal trauma, orthopedics, and rheumatology. PM&R electives included the seven accredited PM&R sub-specializations: brain injury, hospice & palliative medicine, neuromuscular medicine, pain management, rehabilitation medicine, spinal cord injury, and sports medicine.[19] The third and last search iteration was completed in April 2020.

Clinical Quality Measure

The theoretical framework for this analysis was grounded in the six-step approach to curriculum development. Kern developed this approach from generic approaches that advocated

linking curricula to health care needs.[20] He suggested that the development of specific and measurable goals and objectives (step three of six) drives and enables the design of effective educational strategies, implementation of a curriculum, and the evaluation of a training or program. Thus, a key element in the design, implementation, and evaluation of effective clinical clerkships is the creation of measurable objectives.

The Liaison Committee on Medical Education mandates that US medical schools, and faculty, employ a variety of tools to assess students. However, to date, there are no "standardized, consistent, and reliable standards"[21(p1071)] to evaluate undergraduate clerkships.[21,22] Whereas standards exist for musculoskeletal residency specialties (e.g., sports medicine, osteopathic medicine), none exist for PM&R. In 2014, the Accreditation Council for Graduate Medical Education (ACGME) published The Physical Medicine and Rehabilitation Milestone Project[23] to provide a framework for the assessment of residents in ACGME-accredited residency or fellowship programs. On July 1, 2019, the PM&R residency requirements were incorporated into the ACGME Common Program Requirements for training of residents and fellow physicians.[24]

This study uses the ACGME residency requirements as a reference standard. Of particular interest is Section IV, Educational Program, Part B of the ACGME requirements. This part outlined "the required domains for a trusted physician to enter autonomous practice."[24(p18)] As shown in Supplemental Table 2, this study focused on patient care and procedural skills because the focus of the study is clinical skills. The ACGME standard divides these skills into eight competencies related to "evaluation and management of patients with physical and/or cognitive impairments, disabilities, and functional limitations,"[24(p20)] and two competencies

related to "all medical diagnostic, and surgical procedures considered essential for the area of practice."[24(p21)]

However, some of the residency competencies had to be adjusted. In contrast to residency, the purpose of clerkships is domain knowledge, not mastery of practice.[25] Furthermore, instead of four years, clerkship students have up to four weeks. Thus, the milestones that residents are expected to achieve were translated into milestones for typical graduating medical students (ACGME Level 1[23]). For example, it would be unrealistic to expect a medical student to interpret 200 complete electrodiagnostic evaluations in a clerkship, so the objective was modified to understanding of electrodiagnostic evaluations. These modifications are presented in Supplemental Table 3.

Clinical Quality Assessment

The goal was to compile a list of all required and selective PM&R objectives. However, selective objectives were unavailable online and attempts to obtain them directly from the programs were unsuccessful. On the other hand, attempts to obtain required objectives either online ($n = 2$) or directly from the programs ($n = 2$) were successful. In addition, 10% of PM&R electives were sampled in order to assess any deviations from required clerkships. This was accomplished by sampling the first 10% of schools with online elective objectives. Next, the modified list of ACGME objectives (Supplemental Table 3) was applied to the objectives of each program. For example, the text "provide the student with the ability to take a functional history and to develop…" was coded as "pertinent history" (to PM&R). This process was completed in an iterative fashion using the two physiatrists as subject matter experts. The first iteration was completed independently; the entire team then met to discuss any differences and the process continued until consensus. In addition, an emergent design was adopted to identify objectives not

captured in the criterion standard. These objectives were extracted from program curricula and clustered into themes. For example, pain management included myofascial manual techniques, neuroablation, and neurolytic blocks.

Results

Clinical Representativeness

As shown in Table 1, all medical schools required a clerkship in medicine, obstetrics & gynecology, pediatrics, psychiatry, and surgery. It is also shown that most (>50%) programs required clerkships in family medicine (96%), neurology (85%), and emergency medicine (58%), and that some (10-49%) required clerkships in critical care (31%), ambulatory (18%), radiology (15%), anesthesiology (14%), and geriatrics (13%). As indicated in Table 2, few medical schools (<10%) required clerkships in palliative care (5%), PM&R (2%), orthopedic surgery (1%), rehabilitation medicine (1%), musculoskeletal medicine (0.6%), and pain management (0.6%). It should be noted that rehabilitation medicine was embedded in a neurology and rehabilitation clerkship. It should also be noted that, unlike other required clerkships, the median of musculoskeletal and PM&R instruction was two weeks. As DiGiovanni et al.[10] note, only anesthesiology was comparable in terms of duration (mode and median).

Table 3 presents the frequency and measures of central tendency for available musculoskeletal and PM&R sub-specialty electives and selectives. Combined, most (≥ 50%) schools offered optional clerkships in orthopedic surgery (95%), rheumatology (84%), palliative medicine (65%), PM&R (64%), sports medicine (63%), and pain management (63%). Some (10-49%) schools offered optional clerkships in rehabilitation medicine (38%), musculoskeletal radiology (27%), spinal cord injury (25%), and musculoskeletal medicine (12%). Of this combined list, schools specified selectives in orthopedic surgery (n = 20, 13%), rehabilitation

medicine (*n* = 6, 4%), palliative medicine (*n* = 4, 2%), and PM&R (*n* = 3, 2%). Other selective rotations (*n* = 1, <1%) were offered in musculoskeletal medicine, pain management, rheumatology, and spinal cord injury. Altogether, some programs offered musculoskeletal medicine (15%), and few offered PM&R sub-specialty (8%) or PM&R (2%), selectives. The length mode of these selective clerkships was four weeks with the exception of spinal cord injury which lasted one week. No selective rotations were offered for brain injury medicine, musculoskeletal radiology, musculoskeletal trauma, neuromuscular medicine, or sports medicine. Combined, 97% (*n* = 141 of 144) of medical schools offered at least one clerkship opportunity in musculoskeletal medicine (musculoskeletal medicine, musculoskeletal radiology, musculoskeletal trauma, orthopedics, and rheumatology) and 93% (*n* = 135 of 144) offered at least one clerkship opportunity in PM&R or a PM&R sub-specialty (brain injury, hospice & palliative medicine, neuromuscular medicine, pain management, rehabilitation medicine, spinal cord injury, and sports medicine).

Clinical Quality (modified ACGME objectives)

As shown in Table 4, most programs (>50%) included objectives for assessment of impairment (100%), medical history (92%), physical exam (92%), therapeutic prescriptions (92%), electrodiagnostic evaluations (76%), and therapeutic & diagnostic injections (61%). Some programs (10-49%) assessed bioethical decision-making (46%), prescriptions for mobility medical devices (46%), imaging review and interpretation (38%), pediatric rehabilitation (38%), laboratory review and interpretation (15%), and geriatric rehabilitation (15%) objectives.

Next, total, required, and elective objectives were contrasted. Percentage differences of 50% or more were scrutinized and deemed significant (e.g., 10% vs. 60% but not 10% vs. 50%). It was found that whereas all required clerkships assessed medical bioethics, bioethics was only

noted in the objectives of 22% of electives. In addition, geriatric rehabilitation was assessed in 50% of required programs, but in no elective programs. Thus, bioethics and geriatric rehabilitation were disproportionately assessed in required clerkships. On the other hand, therapeutic & diagnostic injections objectives were assessed in 77% of elective, but only 25% of required clerkships. Lastly, most programs defined therapeutic prescriptions as providing prescription of evaluation and treatment by physical therapists (61%), occupational therapists (53%), and speech pathologists (53%). Only some mentioned recreational specialists (23%), psychologists (15%), or vocational counselors (15%). Altogether, most (≥50%) required and electives programs assessed half (6 of 12) of the PM&R modified ACGME objectives (required=66%; electives=50%).

Clinical Quality (thematic analysis)

Table 5 presents the objectives that most (≥50%) and some (10% – 49%) medical schools offered above and beyond the modified ACGME objectives. Altogether, 29 additional objectives assessed by most (n = 14) or some (n = 15) medical schools were identified. As shown in Table 5, the objectives of understanding multidisciplinary team/approach, function-based approach/assessment, management plan/goals, and communication with patients/family were assessed in all required PM&R clerkships. An analysis of significant (≥ 50%) percentage difference (PD) among objectives offered by required and elective clerkships revealed that communication with patients and family (PD = 56%) , differential diagnostic (PD = 53%), and diagnostic evaluation plan (PD = 50%) were disproportionately emphasized in required clerkships. On the other hand, orthopedic rehabilitation (PD = 55%) and spinal cord (PD = 52%) care were disproportionately emphasized in elective clerkships. As shown in Supplemental Table 4, in addition to the six allied health professionals mentioned in the ACGME

"prescription of evaluation and treatment" objective (physical therapists, occupational therapists, speech/language pathologists, recreational specialists therapist, psychologists, vocational counselors), most programs added consulting physicians (69%). Some (10 – 49%) also included rehabilitation nurses (38%), consultants in general (30%), social workers (30%), and therapists in general (30%). Lastly, only a few (<10%) required programs assessed understanding of working with dietitians (7%), discharge planners (7%), and respiratory therapists (7%).

Ancillary Findings

When reviewing program objectives three noteworthy issues were found. First, some objectives were rather general or specific. For example, neurorehabilitation is a general description of head/brain injury, neuromuscular diseases, spacticity management, and stroke. Another example is the use of broad terms such as "consultants" or "therapies". On the other hand, myofascial manual techniques, neuroablation, and neurolytic blocks are specific examples of pain issues or management. Similarly, osteoarthritis, carpal tunnel syndrome, and tendonopathy are specific examples of musculoskeletal injuries/care. Second, some objectives represented required steps in the measurement of other objectives. Differential diagnostic and indications for common diagnostic tests, for example, are required steps in developing a diagnostic evaluation plan. Third, some missing objectives were implied. For example, history and physical are implied in completing a comprehensive physical medicine and rehabilitation consultation. Similarly, using culturally competent behaviors implies the application of bioethical principles.

Summary

Representativeness. The relatively young specialty of PM&R presents unique contributions for civilian and military medicine alike. Nevertheless, most medical programs fail

to emphasize PM&R clinical skills and continue to focus on the "big eight"[10] of clinical clerkships. It was found that in addition to the traditional core clerkships of medicine, obstetrics & gynecology, pediatrics, psychiatry, and surgery, most medical programs required clerkships in family medicine, neurology, and emergency medicine. Only 4 of 154 (2%) medical programs required a PM&R clerkship and only 7 of 154 (4%) required a musculoskeletal rotation (general musculoskeletal, orthopedic surgery, PM&R). In addition, it was found that 11 of 154 (7%) medical schools required a PM&R sub-specialty rotation (palliative care, rehabilitation, pain management). These figures are surprising because Dicaprio et al.[8] reported that six medical schools required PM&R clerkships in 2003 and DiGiovanni et al.[10] found seven in 2014-2015. In addition, whereas 4% of medical schools required a musculoskeletal medicine rotation, Dicaprio et al.[8] reported 20.5%, Bernstein et al.[9] 24.4%, and DiGiovanni et al.[10] 15%. Although the account for the decrease in required PM&R clerkships is unknown, the difference in required musculoskeletal rotations is due to methodology. Unlike prior studies, this study did not consider musculoskeletal components (e.g., orthopedics) within the required surgical clerkship as required musculoskeletal clerkship. Instead, it restricted the analysis to standalone specialty or sub-specialty rotations.

It is tempting to suggest that PM&R and musculoskeletal medicine clerkships are underrepresented because medical schools are unable to accommodate such training. However, this intuitive explanation is not supported by the findings. Altogether, 141 of 144 (97.9%) of medical schools offered at least one clerkship opportunity in musculoskeletal medicine (musculoskeletal medicine, musculoskeletal radiology, musculoskeletal trauma, orthopedics, and rheumatology) and 135 of 144 (93.7%) schools offered at least one clerkship opportunity in PM&R or a PM&R sub-specialty (brain injury, hospice & palliative medicine, neuromuscular

medicine, pain management, rehabilitation medicine, spinal cord injury, and sports medicine). These findings suggest that medical schools failed to emphasize, not offer, PM&R and musculoskeletal clerkships. For example, PM&R was offered as an elective in 93 out of 144 (64%) medical programs, but as a selective in only 3 out of 144 (2%). Similarly, orthopedics was offered as an elective in 136 out of 144 (94%) programs, but as a selective in only 20 out of 144 (13%). As Table 3 demonstrates, although most (>50%) medical schools offered elective rotations in rheumatology, palliative medicine, sports medicine, pain management, and rehabilitation medicine, only a few (0-4%) offered them as selective rotations. As DiGiovanni et al.[10] hinted, it is possible that the effects of the campaign to emphasize musculoskeletal medical education during the Bone and Joint Decade (2002-2011) are beginning to wane.

Clinical quality. Goals and objectives are critical drivers in the development of an effective curriculum. Nevertheless, it was found that programs emphasized some objectives and ignored others. In fact, most clerkships only addressed half of the modified ACGME objectives. Furthermore, some objectives were more prominent in required, while others in elective, clerkships. The reason for this inconsistency was not immediately apparent as program-specific resources and interests are not nested in clerkship type (required or elective).

In addition to driving curricular content, objectives enable curriculum evaluation.[26] When analyzing program curricula, 29 objectives were identified over and above the ACGME residency requirements. In determining which objectives are significant, three logic rules were applied: objectives used by most (≥50%) programs, OR objectives used by most (≥50%) required or elective programs, AND objectives that do not violate the writing style trends identified earlier (see ancillary findings). As a result, amputations, analysis of gait, cardiopulmonary disease care, complimentary/alternative care (e.g., acupuncture), and discharge plan were

omitted as standalone objectives due to low total, required, or elective frequency counts (see Table 5). In addition, orthopedic rehabilitation was subsumed in musculoskeletal care/exam. Lastly, the term neurorehabilitation was found to be rather general. The result was a final list of 22 additional objectives and a comprehensive list of allied health professionals (see Supplemental Table 4).

Study Limitations. The most obvious limitation is inherent to the chosen methodology. Although every attempt was made to corroborate the availability of clerkships using multiple web sources and use the latest information, it is possible that some online information was outdated, incomplete, or insufficiently detailed. In addition, despite every attempt, some programs chose not to share or ignored requests to share information. Thus, it was not possible to assess the quality of selective PM&R clerkships. However, there no reason to assume significant differences among selective and elective clerkships. Another obvious limitation was the absence of standardized PM&R clerkship learning objectives. To overcome this problem, modified ACGME residency objectives were used. Then, an empirically based approach was used to test the use of these objectives in undergraduate clerkships.

Conclusions and Practical Applications

In 2005, AAMC reported that physicians do not fully appreciate the importance of musculoskeletal conditions and their associated burden on the American public and healthcare system. AAMC suggested that the lack of appreciation stems from failure to provide clinical musculoskeletal education in medical schools.[27] This attempt to increase awareness and understanding of musculoskeletal conditions coincided with the International Decade of the Bone and Joint (2000-2010),[28] which the US joined in 2002.[27] Both campaigns spawned at least three studies that assessed the presence of required or selective musculoskeletal instruction in

American undergraduate medical education.[8,9,10] All studies found that "musculoskeletal medicine is underrepresented in the American medical school clinical curriculum."[10(p901)]

Almost two decades after the Decade of the Bone and Joint, this study shows that PM&R clinical education in particular, and musculoskeletal education in general, continue to be underrepresented in American undergraduate medical schools. In fact, findings pointed to a surprising decrease in required PM&R and musculoskeletal clerkships. However, unlike prior studies this study also assessed the presence of PM&R and musculoskeletal elective clerkships. Findings suggest that the term "underrepresented" may be inaccurate since most medical schools offered at least one PM&R, or PM&R sub-specialty, clerkship and at least one musculoskeletal clerkship. Instead, data suggests that PM&R and musculoskeletal clinical instruction is "underemphasized," not underrepresented. Hence, the first practical implication from this study is the recommendation to highlight PM&R clerkships by offering them as selectives. This simple solution will draw attention and expose more students to this unique medical specialty. One study found that a single-day physiatry career fair at the University of Pittsburgh significantly increased self-reported interest, understanding, and desire for further PM&R mentorship in first- or second-year medical students.[29] If such is the effect after a single day, one can imagine the impact of a two-[30] or four-week clerkship on medical students.

The second practical implication from this study is the recommendation to standardize PM&R clerkship learning objectives. Of the programs sampled, most failed to address half of the learning objectives set forth by ACGME. This finding may not surprise some since the ACGME requirements were written for graduate PM&R medical education. However, the requirements were modified appropriately for undergraduate students (Level 1[23]). As other authors have noted,[8,9] increasing the amount of instruction is not tantamount to increasing the quality of

instruction. Thus, findings may be indicative of a problem with the quality of existing PM&R clerkships. As a solution, this paper proposes a novel list of learning objectives.

As shown in Table 6, this list integrates the specificity of the ACGME milestone project[23] and the objectives extracted from PM&R clerkship curricula. Hence, the list has the academic and practical (empirical) rigor of a quality curriculum. Physiatrists, researchers, medical school administrators, and the medical community in general are invited to test the list of proposed objectives and suggest modifications. Doing so may help medical educators honor "the professional and ethical obligation they have to meet the needs of their learners, patients, and society",[20(p17)] as well as to "be held accountable for the outcomes of their interventions."[20(p17)]

Acknowledgement

The authors would like to thank the medical schools that made their curricula easily accessible online. Special gratitude is also extended to the programs that responded to the request for information amidst the COVID-19 pandemic.

References

1. Association of Academic Physiatrists. What is physiatry? An overview website. https://www.physiatry.org/page/WhatIsPhysiatry. Accessed June 19, 2019.
2. Dillingham TR. Physiatry, physical medicine, and rehabilitation: historical development and military roles. *Phys Med Rehabil Clin N Am*. 2002;13(1):1-16. doi:10.1016/S1047-9651(03)00069-X
3. VanDamme TM, Myers KP, Pasquina PF. Physical medicine and rehabilitation within the department of defense. *Austin Med Sci*. 2016;1(2):1008.
4. Le B, Parziale JR. Pre-clinical medical students' attitudes toward physical medicine and rehabilitation. *R I Med J*. 2019;102:26.
5. Tederko P, Krasuski M, Denes Z, Moslavac S, Likarevic I. What medical doctors and medical students know about physical medicine and rehabilitation: a survey from central Europe. *Eur J Phys Rehabil Med*. 2016;52:597-605.
6. Khosrawi S, Ramezanian H, Mollabashi R. Survey of medical students' attitude and knowledge toward physical medicine and rehabilitation in Isfahan university of medical sciences. *J Educ Health Promot*. 2018;7:51-51. doi:10.4103/jehp.jehp_180_16
7. Tederko P, Krasuski M, Nyka I, Denes Z. Knowledge of physical and rehabilitation medicine among physicians and medical students in Poland. Wiadomosci lekarskie (Warsaw, Poland: 1960). 2015;68:123.
8. DiCaprio M, Covey A, Bernstein J. Curricular requirements for musculoskeletal medicine in American medical schools. *J Bone Joint Surg Am*. 2003;85A:565-567.

9. Bernstein J, Garcia G, Guevara J, Mitchell G. Progress report: the prevalence of required medical school instruction in musculoskeletal medicine at decade's end. *Clin Orthop Relat Res*. 2011;469:895-897. doi:10.1007/s11999- 010-1477-3

10. DiGiovanni BF, Sundem LT, Southgate RD, Lambert DR. Musculoskeletal medicine is underrepresented in the American medical school clinical curriculum. *Clin Orthop Relat Res*. 2016;474(4):901-907. doi:10.1007/s11999-015-4511-7

11. Khorsand D, Khwaja A, Schmale G. Early musculoskeletal classroom education confers little advantage to medical student knowledge and competency in the absence of clinical experiences: a retrospective comparison study. *BMC Med Educ*. 2018;18:46-46. doi:10.1186/s12909-018-1157-7

12. Kirshblum SC, Delisa JA, Campagnolo DL. Mandatory clerkship in physical medicine and rehabilitation: effect on medical students' knowledge of physiatry. *Arch Phys Med Rehabil*. 1998;79:10-13. doi:10.1016/s0003- 9993(98)90199-x

13. Faulk C, Mali J, Mendoza P, Musick D, Sembrano R. Impact of a required fourth-year medical student rotation in physical medicine and rehabilitation. *Am J Phys Med Rehabil*. 2012;91:442-448. doi:10.1097/PHM.0b013e31824ad41c

14. DiGiovanni B, Southgate R, Mooney C, Chu J, Lambert D, O'Keefe R. Factors impacting musculoskeletal knowledge and clinical confidence in graduating medical students. *J Bone Joint Surg Am*. 2014;96A:e185-1-7. doi:10.2106/JBJS.M.01283

15. Tham SL, Kong KH. Impact of a week-long rehabilitation medicine posting on third-year medical students' rehabilitation knowledge and attitudes. *Ann Phys Rehabil Med*. 2018;61:e524-e525. doi:10.1016/j.rehab.2018.05.1221

16. Martin R. Physical medicine and rehabilitation in the military: operation Iraqi freedom.

Military Medicine. 2006;171(3): 185-188. doi:10.7205/milmed.171.3.185

17. Monrad SU, Zeller JL, Craig CL, DiPonio LA. Musculoskeletal education in US medical schools: lessons from the past and suggestions for the future. *Curr Rev Musculoskelet Med*. 2011;4:91-98. doi:10.1007/s12178-011-9083-x

18. AAMC Medical School Members website. https://members.aamc.org/eweb/DynamicPage.aspx?site=AAMC&webcode=AAMCOrgSearchResult&orgtype=Medical%20School. Accessed August 6, 2019.

19. Association of Academic Physiatrists. What is physiatry? More resources: fellowship opportunities. https://www.physiatry.org/page/WhatIsPhysiatry. Accessed February 4, 2020.

20. Kern KE. A six-step approach to curriculum development. In: Thomas PA, Kern DE, Hughes MT, Chen BY, eds., *Curriculum development for medical education*. 3rd ed. John Hopkins University Press; 2016.

21. Alexander EK, Osman NY, Walling JL, Michell VG. Variation and imprecision of clerkship grading in U.S. medical schools. *Academic Medicine* 2012;87:1070-1076. doi:10.1097/ACM.0b013e31825d0a2a

22. Durning SJ, Hemmer PA. Commentary: Grading: what is it good for? *Acad Med*. 2012;87:1002-1004. doi:10.1097/ACM.0b013e31825d0b3a

23. The physical medicine and rehabilitation milestone project. *J Grad Med Educ*. 2014;6(1 Suppl 1):207-221. doi:10.4300/JGME-06-01s1-26

24. ACGME program requirements for graduate medical education in physical medicine and rehabilitation website.

https://www.acgme.org/Portals/0/PFAssets/ProgramRequirements/340_PhysicalMedicineRehabilitation_2019_TCC.pdf?ver=2019-03-27-090248-423. Accessed 10 August 2019.

25. Pangaro L, Cate OT. Frameworks for learner assessment in medicine: AMEE guide No. 78. *Med Teach*. 2013;35(6):e1197-e1210. doi:10.3109/0142159X.2013.788789

26. Thomas PA. Goals and objectives. In: Thomas PA, Kern DE, Hughes MT, Chen BY, eds., *Curriculum development for medical education*. 3rd ed. John Hopkins University Press; 2016.

27. Association of American Medical Colleges. *Contemporary issues in medicine: musculoskeletal medicine education*. AAMC; 2005.

28. Lidgren, L. The bone and joint decade 2000–2010. *Bull World Health Organ*. 2003; 81(9):629-629. https://apps.who.int/iris/handle/10665/72122

29. Brane LB, Carson R, Susmarski AJ, Lewno AJ, Dicianno BE. Changing perception: outcomes from a physical medicine and rehabilitation medical student interest fair. *Am J Phys Med Rehabil*. 2017;96:362-365. doi:10.1097/phm.0000000000000583

30. Lalka A, Caldwell R, Black A, Scott FA. An evaluation of the effectiveness of a medical school musculoskeletal curriculum at an academic medical center. *Higher Learning Research Communications*. 2018;8:55-63. doi: 10.18870/hlrc.v8i2.422

Figure Legends

Supplemental Figure 1 Multi-method study design

Table 1. Frequency and length of time (weeks) for required clerkships by most and some medical schools

n = 154	*n*(%)	Mean	Median	Mode	*SD*	DiGiovanni
Medicine	154(100)	8.64	8.00	8.00	1.86	10 ± 2 (100%)
ObGyn	154(100)	6.15	6.00	6.00	1.06	6 ± 1 (100%)
Pediatrics	154(100)	6.60	6.00	6.00	1.19	7 ± 1 (100%)
Psychiatry	154(100)	5.31	6.00	6.00	1.17	5 ± 1 (100%)
Surgery	154(100)	7.90	8.00	8.00	1.51	8 ± 2 (100%)
Family Medicine	149(96)	5.56	6.00	4.00	1.49	6 ± 2 (96%)
Neurology	131(85)	3.91	4.00	4.00	1.01	4 ± 1 (81%)
Emergency Medicine	90(58.4)	3.73	4.00	4.00	0.84	3 ± 1 (55%)
Critical Care	48(31)	3.59	4.00	4.00	0.98	3 ± 1 (30%)
Ambulatory	28(18)	3.96	4.00	4.00	1.02	—
Radiology	24(15)	2.86	2.00	4.00	1.15	3 ± 1 (26%)
Anesthesiology	22(14)	1.89	2.00	2.00	0.66	2 ± 1 (23%)
Geriatrics	21(13)	3.28	4.00	4.00	1.32	—

Note. dash(—) = data not reported. Most is defined as ≥ 50% and some is defined as 10-49%. Medicine includes internal medicine and inpatient medicine. Family medicine includes primary medicine. Radiology includes diagnostic radiology. Critical care includes intensive care unit. DiGiovanni et al.[10] data, weeks ± SD (%required), may not be comparable due to methodological differences.

Table 2. Frequency and length of time (weeks) for required musculoskeletal and PM&R clerkships

n = 154	*n*(%)	Mean	Median	Mode	*SD*
Palliative Medicine	8(5)	3.20	2.00	1.00	2.95
PM&R	4(2)	2.50	2.00	2.00	1.00
Orthopedic Surgery	2(1)	1.00	1.00	1.00	0.00
Rehabilitation Medicine	2(1)	1.00	1.00	1.00	0.00
MSK Medicine	1(0.6)	2.00	—	—	—
Pain Management	1(0.6)	2.00	—	—	—

Note. MSK = Musculoskeletal.

Table 3. Frequency and length of time (weeks) for musculoskeletal and PM&R elective and selective clerkships

	n(%)		*M*(*SD*)		*n*(%)
n = 144	Elective	Selective	Elective	Selective	Total
Orthopedic Surgery	136(94%)	20(13%)	3.84(0.75)	3.76(0.83)	137(95%)
Rheumatology	121(84%)	1(<1%)	3.91(0.66)	4.00(0.00)	121(84%)
Palliative Medicine	94(65%)	4(2%)	3.63(1.00)	3.25(1.50)	95(65%)
PM&R	93(64%)	3(2%)	3.83(0.54)	3.33(1.15)	93(64%)
Sports Medicine	92(63%)	0(0%)	3.67(0.90)	—	92(63%)
Pain Management	91(63%)	1(<1%)	3.66(0.76)	4.00(0.00)	91(63%)
Rehabilitation Medicine	56(38%)	6(4%)	3.69(0.70)	3.33(1.21)	56(38%)
MSK Radiology	40(27%)	0(0%)	3.46(.90)	—	40(27%)
Spinal Cord Injury	35(24%)	1(<1%)	3.64(0.73)	1.00(0.00)	36(25%)
MSK Medicine	17(11%)	1(<1%)	3.75(0.68)	4.00(0.00)	18(12%)
Brain Injury Medicine	12(8%)	0(0%)	3.83(0.57)	—	12(8%)
MSK Trauma	10(6%)	0(0%)	3.66(0.70)	—	10(6%)
Neuromuscular Medicine	6(4%)	0(0%)	4.00(0.00)	—	6(4%)

Note. *M* = Mean. MSK = musculoskeletal. Orthopedic includes orthopedic surgery or orthopedics. Rehabilitation includes rehabilitation medicine or pediatric rehabilitation. Sports medicine includes sports orthopedics or women's sports medicine. *Total* represents medical schools, not individual selective and elective rotations. All modes and medians = 4.00.

Table 4. Frequency and percent of modified ACGME objectives in required and elective PM&R clerkships

n(%)	Required *n* = 4	Elective *n* = 9	Total *n* = 13
Assessment of impairment	4(100)	9(100)	13(100)
Medical History	4(100)	8(88)	12(92)
Physical Exam	4(100)	8(88)	12(92)
Therapeutic prescriptions	4(100)	8(88)	12(92)
Physical therapist	1(25)	7(77)	8(61)
Occupational therapist	1(25)	6(66)	7(53)
Speech/language pathologist	1(25)	6(66)	7(53)
Recreational specialist	0(0)	3(33)	3(23)
Psychologist	1(25)	1(10)	2(15)
Vocational counselor	1(25)	1(10)	2(15)
Electrodiagnostic evaluation	2(50)	8(88)	10(76)
Therapeutic & diagnostic injections	1(25)	7(77)	8(61)
Bioethical decision-making	4(100)	2(22)	6(46)
Prescriptions for mobility medical devices	2(50)	4(44)	6(46)
Imaging review & interpretation	1(25)	4(44)	5(38)
Pediatric rehabilitation	1(25)	4(44)	5(38)
Laboratory review & Interpretation	1(25)	1(11)	2(15)
Geriatric rehabilitation	2(50)	0(0)	2(15)

Note. The following logic function was used=If therapist, then therapeutic prescription

Table 5. Frequency and percent of most and some required, elective, and total objectives extracted from thematic analysis

n(%)	Required *n* = 4	Elective *n* = 9	Total *n* = 13
Musculoskeletal care	3(75)	9(100)	12(92)
Multidisciplinary team/approach	4(100)	8(88)	12(92)
Function-based assessment	4(100)	7(77)	11(84)
Inpatient practice	3(75)	7(77)	10(76)
Management plan/goals	4(100)	6(66)	10(76)
Outpatient practice	3(75)	7(77)	10(76)
Pain management	3(75)	6(66)	9(69)
Treatment plan/goals	3(75)	6(66)	9(69)
Communication with patient/family	4(100)	4(44)	8(61)
Neurorehabilitation	3(75)	5(55)	8(61)
Spinal cord injury care	1(25)	7(77)	8(61)
Head/brain injury care	2(50)	5(55)	7(53)
Neuromuscular diseases care	3(75)	4(44)	7(53)
Sports/occupational injuries care	2(50)	5(55)	7(53)
Communication with team	3(75)	3(33)	6(46)
Case presentations	2(50)	4(44)	6(46)
Spacticity management	1(25)	5(55)	6(46)
Stroke care	1(25)	5(55)	6(46)
Differential diagnostic	3(75)	2(22)	5(38)
Orthopedic rehabilitation	0(0)	5(55)	5(38)
Secondary prevention	2(50)	3(33)	5(38)
Amputations	1(25)	2(22)	3(23)
Analysis of gait	1(25)	2(22)	3(23)
Cardiopulmonary disease care	1(25)	2(22)	3(23)
Complimentary/Alternative care	1(25)	2(22)	3(23)
Indications for diagnostic tests	2(50)	1(11)	3(23)
Psychosocial issues	2(50)	1(11)	3(23)
Diagnostic evaluation plan	2(50)	0(0)	2(15)
Discharge plan	1(25)	1(11)	2(15)

Note. Most is defined as ≥ 50% and some is defined as 10-49%. This list does not include objectives noted in Table 4.

Table 6. Proposed standardized physical medicine & rehabilitation clerkship learning objectives

Goal:

- To provide a program of instruction to medical students that instills cognitive proficiency in physical medicine & rehabilitation procedures and practices
- To inform selection of postgraduate training/career and promote holistic medical education

Objectives: By the end of the physical medicine & rehabilitation clerkship, the students must demonstrate understanding in the evaluation and management of patients with physical and/or cognitive impairments, disabilities, and functional limitations, including:

Patient Care

PC 1. History[a] *(Appropriate for age and impairment)*

a. Acquires a general medical history

b. Acquires a basic physiatric history, including medical, functional, and psychosocial[b] elements

PC 2. Physiatric Physical Examination[a] *(including general medical, neurologic, musculoskeletal, and gait adapted for age and impairment)*

a. Performs a general physical exam

b. Performs a physical exam that assists in functional assessment (e.g., may include balance, gait, cognition, neurologic, or musculoskeletal assessments)[b]

c. Begins to identify normal and pathologic findings

PC 3. Diagnostic Evaluation

a. Demonstrated understanding of differential diagnosis for common medical conditions and conditions commonly seen in physiatric practice[b]

b. Identifies indications for diagnostic studies of common medical conditions and conditions commonly seen in physiatric practice[b]

c. Demonstrates understanding of integrating functional assessment measures into overall evaluation[b]

d. Identifies basic imaging[a] (including ultrasound), review, and interpretation commonly seen in physiatric practice

e. Identifies basic electrodiagnostic studies (including electromyography), review, and interpretation commonly seen in physiatric practice[a]

f. Identifies basic laboratory testing, review, and interpretation commonly seen in physiatric practice[a]

PC 4. Medical Management and Planning

a. Demonstrates an understanding of evidence-based medical management plan/goals[a]

b. Identifies prevention and management of common medical complications associated with neurological, neuromuscular, and musculoskeletal injuries, diseases, and interventions (e.g., amputations, dysreflexia, pressure, prophylaxis, stroke, ulcer)[b]

c. Demonstrates an understanding of using differential diagnostics, indications for common diagnostic tests, and appropriate medical consultations in developing treatment plan/goals[b]

PC 5. Rehabilitation/Functional Management

a. Describes basic impairments, activity limitations, and participation restrictions resulting from disease or injury[a]

b. Demonstrate knowledge of basic prescriptions of appropriate rehabilitation therapies such as:

b(1). Physical therapy[a]

b(2). Occupational therapy[a], and
b(3). Speech therapy[a]
c. Demonstrates understanding of prescriptions for orthotics, prosthetics, wheelchairs, assistive devices for ambulation, and other durable medical equipment or assistive devices[a]
d. Demonstrates understanding of basic rehabilitation interventions in:
d(1), Inpatient setting[b]
d(2). Outpatient setting[b]

PC 6. Procedural Skills *(not including axial injections)*
a. Identifies basic joint and soft tissue injection (e.g., tendons, trigger point) interventions[a]
b. Identifies basic spasticity injection (e.g., chemodenervation, botulinum toxin) interventions[b]
c. Identifies basic guided (e.g., electromyography-, ultrasound-, fluoroscopy-) procedures[b]

PC 7. Procedural Skills: Electrodiagnostic **Procedures**[a]
a. Describe basic anatomy of peripheral nerves and skeletal muscle
b. Identifies sites of stimulation for nerves commonly studied
c. Identifies sites of electromyography needle insertion in muscles commonly studied

Medical Knowledge

MK. Care for core medical conditions and basic preventive care of:
Demonstrates basic medical knowledge to provide care for common medical conditions and basic preventive care to include:

- Brain disorders *(including traumatic and non-traumatic etiologies; excluding stroke)*[b]
- Geriatric disorders[a]
- Musculoskeletal disorders (e.g., orthopedics, rheumatology, osteoarthritis , carpal tunnel syndrome, tendonopathy)[b]
- Neuromuscular disorders (e.g., myopathies, cerebral palsy, radiculophathy)[b]
- Pain (Including myofascial manual techniques, neuroablation, neurolytic blocks)[b]
- Pediatric disorders[a]
- Spasticity[b]
- Spinal cord disorders[b]
- Sports/occupational injuries[b]
- Stroke[b]

Systems-Based Practice

SBP 1. Systems thinking
a. Describes and differentiates between the various systems of care in which rehabilitation is provided (e.g., acute care, inpatient rehabilitation facility, outpatient, etc.)

SBP 2. Team Approach
Understand the roles of the following team members in patient care[b]:
1. Consulting physician
2. Physical therapy[a]
3. Occupational therapy[a]
4. Speech therapy[a]
5. Nurse[b]
6. Social worker[b]
7. Therapists[b]
8. Recreational therapist[a]
9. Psychologist[a]

10. Vocational therapist[a]
11. Dietician[b]
12. Discharge planner[b]
13. Respiratory therapist[b]
Professionalism
PROF 1. Demonstrates compassion, integrity, respect, sensitivity, and responsiveness in routine interactions with patients, families, and team members
PROF 2. Respect for, and adherence to the ethical principles
a. Demonstrates awareness of bioethics principles to decision making in the diagnosis and management of patients (e.g., declining a feeding tube, using culturally competent behaviors, use of patient-centered, rather than disease-oriented medical ethic)[a]
PROF 3. Professional behaviors & accountability to self, patients, society, and profession
a. Demonstrates professional accountability (e.g., timely completion of professional responsibilities and being dressed and groomed appropriately)
Interpersonal and Communication Skills
ICS. Relationship Management
a. Identifies factors that affect communication in patients (e.g., language, speech, hearing, vision, and cognitive impairments)[b]
b. Identify the factors that forms positive interpersonal relationships (e.g., supportive response to patient's emotions, active listening, responsiveness to needs) when interacting with patients in uncomplicated situations[b]
c. Demonstrate effective verbal and non-verbal communication strategies (including active listening, augmentative communication devices, interpreters, etc.)
d. Demonstrate effective communication with patient/family[b]
e. Demonstrate effective communication with health care team (identify members from SBP 2. Team Approach)[b]
f. Demonstrates effective communication in presenting patient case studies[b]

Note. [a]modified ACGME objectives. [b]objectives extracted from thematic analysis. Format adapted from The Physical Medicine and Rehabilitation Milestone Project[23]

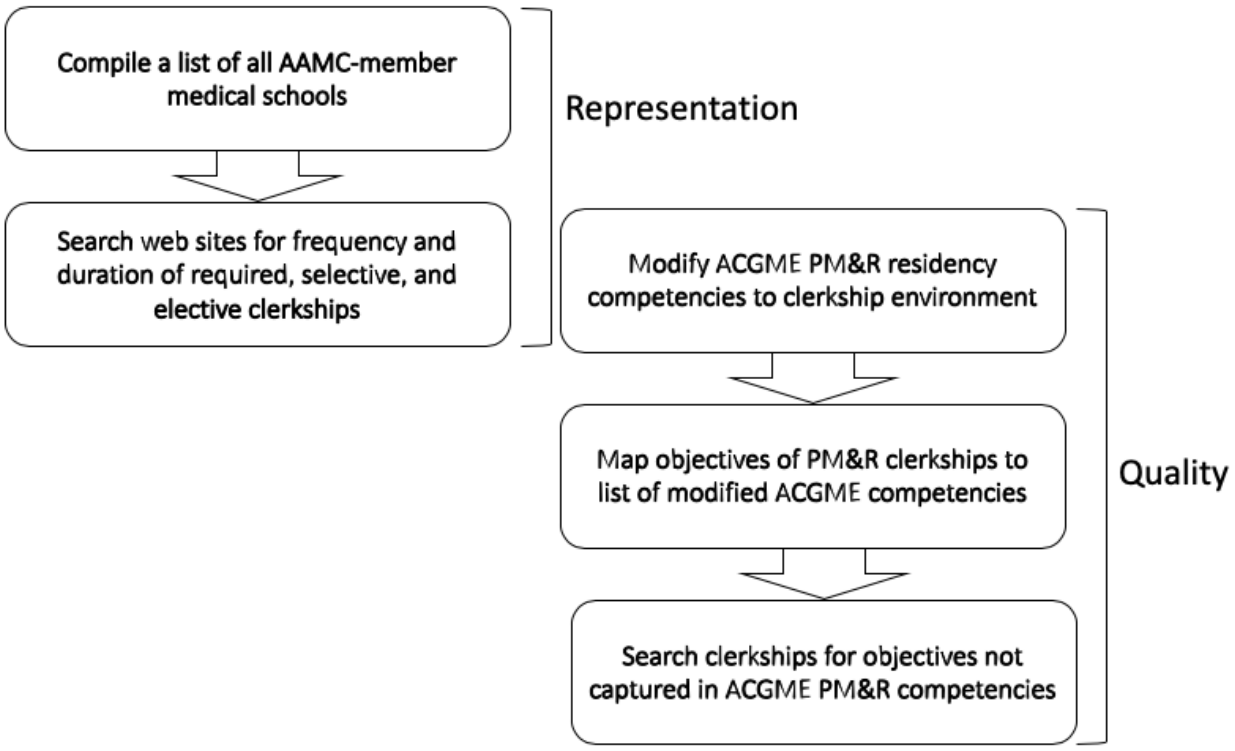
Supplemental Digital Content

Supplemental Figures

Supplemental Tables

Supplemental Figure 1

Multi-method study design



Supplemental Table 1

Summary of prior studies for musculoskeletal representation

	DiCaprio et al.[8]	Bernstein et al.[9]	DiGiovanni et al.[10]
Year	2003	2011	2016
Medical Schools, *n*	122	127	136
Required preclinical instruction, *n*(%)	51(41%)	100(78%)	—
Required clerkships, *n*(%)	25(20%)	31(24%)	20(15%)
Required clerkship rotation (*M* weeks)	2	—	2
Required PM&R clerkship, *n*(%)	6(4.9%)	—	7(5%)
No required instruction at all	57(46%)	21(16%)	—

Note. *M* = mean. dash(—) = data not reported. Musculoskeletal clerkships included orthopedics, rheumatology, or PM&R. DiGiovanni et al. also included primary care sports medicine.

Supplemental Table 2

ACGME Competencies

Professionalism (IV.B.1.a)
Patient care and procedural skills (IV.B.1.b)
Medical knowledge (IV.B.1.c)
Practice-based learning and improvement (IV.B.1.d)
Interpersonal and communication skills (IV.B.1.e)
Systems-based practice (IV.B.1.f)

Supplemental Table 3

ACGME and modified list of objectives

ACGME objectives	Our modified objectives
Residents must demonstrate competence in the evaluation and management of patients with physical and/or cognitive impairments, disabilities, and functional limitations, including: IV.B.1.b).(1).(a)	Students must demonstrate understanding in the evaluation and management of patients with physical and/or cognitive impairments, disabilities, and functional limitations, including:
History and physical examination pertinent to physical medicine and rehabilitation IV.B.1.b).(1).(a).(i)	1. Pertinent physical examination 2. Pertinent history
Assessment of impairment, activity limitation, and participation restrictions IV.B.1.b).(1).(a).(ii)	3. Assessment of impairment, activity limitation, and participation restriction
Review and interpretation of pertinent laboratory and imaging materials for the patient IV.B.1.b).(1).(a).(iii)	4a. Laboratory review and interpretation 4b. Imaging review and interpretation
Providing prescriptions for orthotics, prosthetics, wheelchairs, assistive devices for ambulation, and other durable medical equipment or assistive devices IV.B.1.b).(1).(a).(iv)	5. Prescriptions for orthotics, prosthetics, wheelchairs, assistive devices for ambulation, and other durable medical equipment or assistive devices
Pediatric rehabilitation IV.B.1.b).(1).(a).(v)	6. Pediatric rehabilitation
Geriatric rehabilitation IV.B.1.b).(1).(a).(vi)	7. Geriatric rehabilitation
Application of bioethics principles to decision making in the diagnosis and management of their patients IV.B.1.b).(1).(a).(vii)	8. Bioethics principles to decision making in the diagnosis and management of patients
Providing prescription of evaluation and treatment by physical therapists, occupational therapists, speech/language pathologists, therapeutic recreational specialists, psychologists, and vocational counselors IV.B.1.b).(1).(a).(viii)	9. Prescription of evaluation and treatment by 9a. Physical therapists 9b. Occupational therapists 9c. Speech/language pathologists 9d. Therapeutic recreational specialists 9e. Psychologists 9f. Vocational counselors
Residents must demonstrate competence in the: IV.B.1.b).(2).(a) Performance, documentation, and interpretation of 200 complete electrodiagnostic evaluations from separate patient encounters IV.B.1.b).(2).(a).(i)	Students must demonstrate understanding in: 10. Electrodiagnostic evaluations
Performance of therapeutic and diagnostic injections IV.B.1.b).(2).(a).(ii)	11. Therapeutic & diagnostic injections

Supplemental Table 4

Frequency and percent of required, elective, and total allied health professionals extracted from thematic analysis

	n(%) Required *n* = 4	Elective *n* = 9	Total *n* = 13
Consulting physician	2(50)	7(77)	9(69)
Physical therapist*	1(25)	7(77)	8(61)
Occupational therapist*	1(25)	6(66)	7(53)
Speech therapist*	1(25)	6(66)	7(53)
Nurse	1(25)	4(44)	5(38)
Consultants	1(25)	3(33)	4(30)
Social worker	1(25)	3(33)	4(30)
Therapists	1(25)	3(33)	4(30)
Recreational therapist*	0(0)	3(33)	3(23)
Psychologist*	1(25)	1(11)	2(15)
Vocational therapist*	1(25)	1(11)	2(15)
Dietician	1(25)	0(0)	1(7)
Discharge planner	1(25)	0(0)	1(7)
Respiratory therapist	1(25)	0(0)	1(7)

Note. Asterisk = modified ACGME objectives noted in Table 4.

.

Chapter 3 - Discussion

Military Relevance

The modern practice of physiatry, as well as other rehabilitative professions such as physical therapy and occupational therapy, grew from the rehabilitative needs of soldiers in World War I and World War II.[1,2,3,4] As more warfighters survive physical and psychological battlefield injuries, due to improved armor and improved medical care, the role of rehabilitation becomes more crucial. In the Persian Gulf War, 57% of casualties suffered musculoskeletal injuries and the primary referral service was orthopedics (64%).[5] In Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF), the two most frequent diagnoses among veterans receiving Veteran Health Administration benefits were musculoskeletal system/connective tissue disorders (50%) and mental disorders (45.6%).[6] Although survival rates reached historical highs in OIF and OEF, the devastating injuries of modern warfare resulted in complex co-morbid conditions such as extremity trauma and amputation, paralysis, sensory impairments, traumatic brain injury (TBI), and post-traumatic stress disorder (PTSD).[7] Blast-induced traumatic brain injury and neurotrauma from blast exposure were called the "signature wound" [8(p1257)] of the Afghanistan and Iraq wars. This signature wound inflicted traumatic injuries on thousands of soldiers and an even greater number of civilians.[8]

In order to address these conditions, rehabilitative efforts begin early, sometimes on the battlefield while patients are stabilized and offered aggressive medical intensive care.[5,7] Military physiatrists are uniquely qualified to support this process because they have multidisciplinary training, expertise in neuromuscular medicine, training in integrating medical, surgical, and behavioral health care, and training to assist in other, non-rehabilitation, duties such as triage or trauma life support (as opposed to other staff members such as occupational therapists).[7,9,10] As a

result, physiatrists serve in field aide stations (echelon II), combat support hospitals (echelon III), and fixed hospitals (echelon IV).[7,10] During peacetime, military physiatrists support combat readiness by caring for warriors and their beneficiaries, including pediatric and geriatric populations.[5,7] Despite their crucial role in wartime and in peacetime, there is often a shortage of physiatrists in the military. As a consequence, occupational therapists and physical therapists are authorized to provide primary evaluation and treatment of common musculoskeletal problems.[5,10] This practice may result in incorrect diagnosis and treatment of musculoskeletal problems.[4]

Conclusions

In 2005, AAMC reported that physicians do not fully appreciate the importance of musculoskeletal conditions and their associated burden on the American public and healthcare system. AAMC suggested that the lack of appreciation stems from failure to provide clinical musculoskeletal education in medical schools.[11] This assertion was corroborated by studies that concluded that musculoskeletal medicine is underrepresented in American medical schools.[12,13,14]

Almost two decades after these assertions this study found that PM&R clinical education in particular, and musculoskeletal education in general, continue to be underrepresented in American undergraduate medical schools. In fact, the findings pointed to a surprising decrease in required PM&R and musculoskeletal clerkships. However, unlike prior studies, this study also assessed the presence of PM&R and musculoskeletal elective clerkships. The picture that emerged is that medical schools restrict PM&R and musculoskeletal clinical experience to elective training. Hence, these clerkships are not “underrepresented” but “underemphasized”.

The first practical implication of this study is the recommendation to highlight PM&R clerkships by offering them as selectives. This simple solution will draw attention and expose

more students to this unique medical specialty. One study found that a single-day physiatry career fair at the University of Pittsburgh significantly increased self-reported interest, understanding, and desire for further PM&R mentorship in first- or second-year medical students.[15] If such is the effect after a single day, one can imagine the impact of a two-[16] or four-week clerkship on medical students.

The second practical implication of this study is the recommendation to standardize PM&R clerkship learning objectives. Of the programs sampled, most failed to address half of the learning objectives set forth by ACGME. In addition, programs emphasized different objectives with no apparent rationale. These findings may be indicative of a problem with the quality of existing PM&R clerkships. As a solution, this study proposes a novel list of learning objectives for PM&R clerkships. This list integrates the specificity of the ACGME milestone project[17] and the objectives extracted from PM&R clerkship curricula in this study. Hence, the list has the academic and practical (empirical) rigor of a quality curriculum.

In conclusion, this study drew a distinction between the number of clerkships provided and the incentive to take them. It also addressed a potential problem with the quality of existing clerkships. Lastly, this study produced a novel and comprehensive list of objectives for undergraduate PM&R clerkships. Taken together, this study addressed the need for physiatrists in society by evaluating undergraduate clinical training in US medical schools. It is presented to the medical educators in order to help them be "accountable for the outcomes of their interventions."[18(p17)].

References

1. Lanska DJ. The influence of the two world wars on the development of rehabilitation for spinal cord injuries in the United States and Great Britain. *Frontiers of Neurology and Neuroscience*. 2016;38:56.
2. Lee PKW. Defining physiatry and future scope of rehabilitation medicine. *Annals of Rehabilitation Medicine*. 2011;35(4): 445–449. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3309231/
3. Dillingham TR, Belandres PV. Physiatry, physical medicine, and rehabilitation: Historical development and military roles, 3-18. In: Dillingham TR, Belandres PV, eds., *Rehabilitation of the Injured Combatant Volume 1 (*Textbook of Military Medicine, Part IV Surgical Combat Casualty Care*).* Washington, DC: Office of the Surgeon General; 1998.
4. Greathouse DG, Sweeney J, Hartwick AMR. Physical therapy in a wartime environment, 19-30. In: Dillingham TR, Belandres PV, eds., *Rehabilitation of the Injured Combatant Volume 1 (*Textbook of Military Medicine, Part IV Surgical Combat Casualty Care*).* Washington, DC: Office of the Surgeon General; 1998.
5. Dillingham TR, Spellman NT, Braverman SE, et al. Analysis of casualties referred to Army physical medicine services during the Persian Gulf conflict. *American Journal of Physical Medicine and Rehabilitation*. 1993;72:214–218.
6. Lisi AJ. Management of Operation Iraqi Freedom and Operation Enduring Freedom veterans in a Veterans Health Administration chiropractic clinic: A case series. *Journal of Rehabilitative Research and Development*. 2010;47(1): 1-7.

7. VanDamme TM, Myers KP, Pasquina PF. Physical medicine and rehabilitation within the Department of Defense. *Austin Medical Sciences*. 2016;1(2): 1008.

8. Hicks RR, Fertig SJ, Desrocher RE, Koroshetz WJ, Pancrazio JJ. Neurological effects of blast injury. *The Journal of Trauma: Injury, Infection, and Critical Care*. 2010;68:1257-1263.

9. Martin R. Physical medicine and rehabilitation in the military: The Bosnian mass casualty experience. *Military Medicine*. 2001;166(4): 335–337.

10. Martin R. Physical medicine and rehabilitation in the military: Operation Iraqi Freedom. *Military Medicine*. 2006;171(3): 185-188. https://www.ncbi.nlm.nih.gov/pubmed/16602511

11. Association of American Medical Colleges. *Contemporary issues in medicine: Musculoskeletal medicine education*. AAMC; 2005.

12. DiCaprio M, Covey A, Bernstein J. Curricular requirements for musculoskeletal medicine in American medical schools. *Journal of Bone and Joint Surgery-American Volume*. 2003;85A:565-567.

13. Bernstein J, Garcia G, Guevara J, Mitchell G. Progress report: The prevalence of required medical school instruction in musculoskeletal medicine at decade's end. *Clinical Orthopaedics and Related Research*. 2011;469:895-897. doi:10.1007/s11999-010-1477-3

14. DiGiovanni BF, Sundem LT, Southgate RD, Lambert DR. Musculoskeletal medicine is underrepresented in the American medical school clinical curriculum. *Clinical Orthopaedics and Related Research*. 2016;474(4):901-907. doi:10.1007/s11999-015-4511-7

15. Brane LB, Carson R, Susmarski AJ, Lewno AJ, Dicianno BE. Changing perception: Outcomes from a physical medicine and rehabilitation medical student interest fair. *American Journal of Physical Medicine & Rehabilitation*. 2017;96:362-365. doi:10.1097/phm.0000000000000583

16. Lalka A, Caldwell R, Black A, Scott FA. An evaluation of the effectiveness of a medical school musculoskeletal curriculum at an academic medical center. *Higher Learning Research Communications*. 2018;8:55-63. doi: 10.18870/hlrc.v8i2.422

17. The physical medicine and rehabilitation milestone project. *Journal of Graduate Medical Education*. 2014;6(1 Suppl 1):207-221. doi:10.4300/JGME-06-01s1-26

18. Kern KE. A six-step approach to curriculum development. In: Thomas PA, Kern DE, Hughes MT, Chen BY, eds., *Curriculum development for medical education*. 3rd ed. John Hopkins University Press; 2016.