



AOA Critical Issues in Education

Musculoskeletal Learning and Knowledge Retention Among Postgraduate Physicians: Evaluating the Long-Term Impact of a New Preclerkship Curriculum at a Nationally Accredited Medical Program

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Introduction: Musculoskeletal (MSK) injuries and disorders are exceptionally prevalent in the clinical setting. Despite this, physician training in MSK medicine has been historically inadequate contributing to a lack of MSK knowledge, confidence, and clinical skills among postgraduate physicians. The goal of this investigation was to examine the long-term impact of a new preclerkship MSK curriculum implemented by a nationally accredited medical program on postgraduate physician's learning and knowledge retention in the area of MSK medicine.

Methods: Five hundred sixty-eight postgraduate physicians (years 1–6) who had previously completed the new curriculum over a 6-year period were recruited to complete a standardized and validated MSK examination that consisted of 30 multiple-choice questions on core or must-know topics in MSK medicine that could be directly mapped to learning objectives within the new preclerkship MSK curriculum.

Results: Ninety postgraduate physicians completed the examination, obtaining an average score of 75.0% (± 10.2 ; range 57.0–100.0). Physicians who completed MSK-related electives during clerkship training or specialized in fields related to MSK medicine (i.e., orthopaedics, PM&R, sports medicine, and rheumatology) performed significantly better on the MSK examination ($p \leq 0.01$).

Conclusion: Data indicated that the program's new preclerkship curriculum supports high levels of MSK learning and knowledge retention among postgraduate physicians. These findings are expected to assist with the establishment of minimum curriculum standards and can be used to guide MSK curricular reform at other medical programs.

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (<http://links.lww.com/JBJSOA/A685>).

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Introduction

The treatment of musculoskeletal (MSK) injuries and pathologies represents a significant portion of a physician's daily practice; MSK conditions are the second most common reason a patient visits their primary care physician¹ and cost the North American healthcare system an estimated \$900 billion annually². Despite the significant burden of disease and large socioeconomic cost, a considerable body of evidence indicates that physician training in MSK medicine has historically been absent or insufficient³. Consequently, research illustrates that physicians lack adequate knowledge, confidence, and clinical skills when delivering MSK medicine³⁻¹⁰, with $\geq 50.0\%$ of practicing physicians failing to obtain a passing score on MSK competency examinations¹¹.

Despite national accreditation standards and initiatives designed to improve physician training in MSK medicine, recent evidence confirms that significant heterogeneity exists when comparing the MSK curricula of both Association of Faculties of Medicine of Canada¹² (AFMC)- and American Association of Medical Colleges¹³ (AAMC)-accredited medical programs. In 2015, a nationally accredited medical program implemented a new preclerkship (years 1 and 2 of medical school) MSK curriculum as part of its curriculum renewal process. The new curriculum consisted of 3 distinct sections: 1. a year-1 MSK anatomy course (MSK1) that used a cadaveric-based approach to learning (30.0 hours of instruction); 2. a year-2 MSK medicine course (MSK2) covering core or must-know topics in MSK medicine¹⁴ (68.0 hours of instruction); and 3. hands-on clinical skills training on MSK physical examination (11.0 hours). Our previous research indicated that the new curriculum supported high levels of academic performance, with student feedback on the course's learning environment being exceptionally positive¹⁵. Our research also indicated that the MSK2 curricula "covers" or "covers in detail" 15 of 16 topics in MSK medicine that have been previously identified as core or

must-know content for physicians in all areas of medicine to comprehend¹⁴. By contrast, only 25.0% of these topics were reliably covered by other accredited medical programs^{12,13} (Fig. 1). These data also found that the new preclerkship curriculum provided more time for MSK learning than a majority of Canadian¹² and American¹³ accredited medical programs (Table I). Although these results confirm that this new preclerkship curriculum effectively supports student learning and knowledge acquisition on topics related to MSK medicine, it is unclear whether knowledge is retained by postgraduate physicians from the medical program.

The purpose of this study was to evaluate the long-term impact of the program's new preclerkship MSK curriculum on MSK learning and knowledge retention among postgraduate physicians. It was hypothesized that the new preclerkship MSK curriculum would support high levels of MSK learning and knowledge retention among postgraduate physicians from the institution. Results are expected to help advance the current body of knowledge seeking to improving physician learning and knowledge retention in MSK medicine and confirm the efficacy of a curricular model that could be used by other AFMC- and AAMC-accredited medical programs to enhance preclerkship MSK medicine training.

Materials and Methods

Participants

A total of 654 postgraduate physicians who completed the new preclerkship MSK curriculum at the University of Manitoba, a nationally accredited medical program, including individuals in postgraduate year 1 (PGY1) through year 6 (PGY6), were eligible to participate in this cross-sectional survey. Working with the institution's alumni association, valid email addresses were obtained for 568/654 eligible individuals, and a study advertisement containing a link to an online survey was distributed between September 2023 and March 2024.

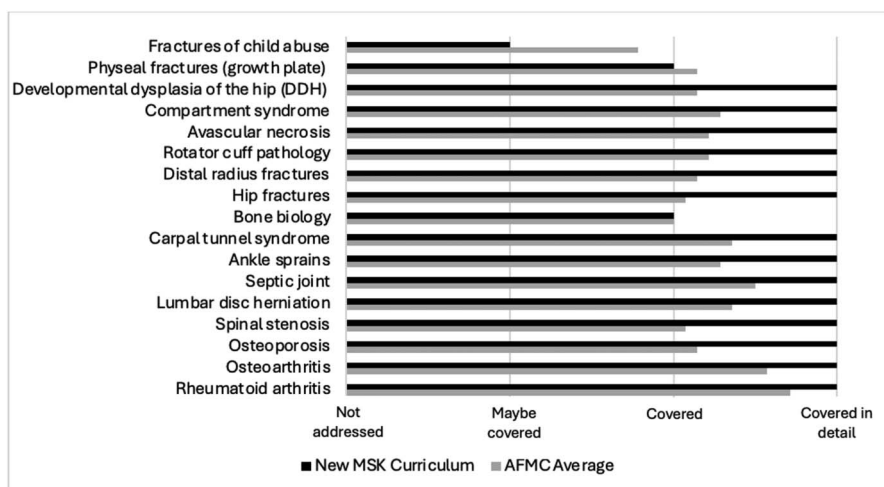


Fig. 1

Core or must-know topics in MSK medicine. Detail with which core or must-know topics in MSK medicine are covered within curricula of nationally accredited medical program¹². MSK = musculoskeletal.

TABLE I MSK Curricular Hours for Nationally Accredited Allopathic Medical Programs*

	Current Program	AFMC Programs ¹² N = 14	AAMC Programs ¹³ N = 11
MSK anatomy	30.0	29.8 (12-60)	29.7 (4-50)
MSK medicine	68.0	58.0 (6-204)	58.7 (6-150)
Clinical skills	11.0	12.6 (3-40)	NA

*Curricular hours devoted to MSK training within nationally accredited program^{12,13}. Mean (range). AAMC = American Association of Medical Colleges, AFMC = Association of Faculties of Medicine of Canada, and MSK = musculoskeletal.

Physicians who completed training before the implementation of the new preclerkship curriculum at this institution or completed their medical degree at another medical program were not eligible to participate.

Survey

All participants were first asked to provide informed consent and complete an online demographic survey (hosted at surveymonkey.com). The survey consisted of 10 questions organized into 3 themes: (1) equity, diversity, and inclusion; (2) educational background; and (3) self-perception of MSK knowledge and confidence in clinical application. The first theme included questions specifying the participant's age, gender identity, and socioeconomic status (SES), which allowed for comparison with AFMC reports regarding postgraduate physician demographics across Canada. The educational theme asked participants to indicate their year of graduation from medical school, self-report their grades from the program's MSK1 and MSK2 courses, specify whether MSK-related electives were completed during the clerkship portion of their medical training (years 3 and 4), and indicate the area of medicine they practiced in as a physician. This facilitated organization of the data into specific cohorts for analysis. The third demographic theme asked participants to rank their confidence when diagnosing MSK conditions in a clinical setting using a 5-point Likert scale (ranging from “no confidence—1” to “complete confidence—5”) and allowed for comparison with findings from previous investigations⁹.

Postgraduate MSK learning and knowledge retention were evaluated through the use of the MSK30 examination¹⁶. This validated and standardized assessment tool comprised 30 multiple-choice questions that each consist of one stem and 4 distractor statements and has been previously used in postgraduate settings to evaluate physician's knowledge on core or must-know MSK topics related to trauma, overuse and sport-related injuries, prevalent diseases (e.g., osteoarthritis and rheumatology), and other clinical implications commonly presented in the clinical setting. The MSK30 tested knowledge and concepts that were taught as part of the program's new preclerkship MSK curriculum and could be directly mapped to

both course- and session-specific learning objectives within the MSK1 and MSK2 curricula.

Statistical Analysis

The MSK30 score (of 100%) served as the primary outcome measure for this study. Each examination question was worth one point, and a raw score of 30 was converted to a percentage for each participant. A test score of 60.0% was set as the passing grade and coincided with the passing grade requirement for all preclerkship courses at the nationally accredited institution. MSK30 scores were organized by participant demographics, and Microsoft Excel software was used to conduct one-way ANOVAs and Pearson correlation coefficient on participant's MSK examination score. Results were considered statistically significant if $p \leq 0.05$.

Results

A total of 90 postgraduate physicians participated in this investigation over the collection period (September 2023–March 2024)—representing approximately 1 in every 6 physician graduates from the program. A similar response rate was observed for each year of graduates (PGY1-PGY6), and data were collected on a heterogeneous group of physicians across gender, age, and SES (Table II). Of the 90 postgraduate physicians, 68 (75.6% of respondents) reported achieving a grade greater than or equal to 80% in both preclerkship MSK courses, and only 30 physicians (33.3% of respondents) reported completing any type of MSK-related electives during their clerkship training. The sample comprised physicians who reported practicing in a variety of medical fields (e.g., cardiology, neurology, ophthalmology, emergency medicine, and pediatrics); however, family medicine was the most common area of practice (56.5%).

MSK30 results indicated that postgraduate physicians who completed the new preclerkship MSK curriculum achieved a mean examination score of 75.0% (± 10.2 , range 57.0–100.0) with only 3.3% of participants failing to obtain a passing score of $\geq 60.0\%$ (Fig. 2). No significant differences were observed in examination scores when comparing postgraduate years (PGY1: 74.2 ± 13.4 , PGY2: 71.8 ± 8.6 , PGY3: 72.1 ± 11.5 , PGY4: 77.9 ± 8.2 , PGY5: 73.9 ± 10.5 , and PGY6: 79.5 ± 7.9) ($p \leq 0.05$). These results were comparable with the mean grades achieved by each cohort when completing the program's new preclerkship curricula during medical training^{15,17,18} (Fig. 3). In addition, no significant differences in examination scores were noted between groups when data were organized by demographic variables such as age, gender, or SES ($p \leq 0.05$). Pearson correlation coefficient testing illustrated that previous academic performance in the program's MSK1 and MSK2 courses was not a predictor of success on the examination ($r = 0.05$), and no significant differences were found between postgraduate years (PGY1-PGY6) when data were organized according to previous academic performance within the new preclerkship curriculum ($p \leq 0.05$).

Postgraduate physicians reported a mean confidence rating of 2.6/5.0 (± 0.9 , range 1.0–5.0) when using a 5-point Likert scale to grade their clinical confidence in MSK medicine. No significant

TABLE II Demographic Distribution of Postgraduate Physician from PGY1 to PGY6*

	Gender		Age			Socioeconomic status		
	Man	Woman	18-23	24-29	30+	Low	Middle	High
Postgraduate physicians								
PGY1 (n = 11)	45.5%	54.5%		81.8%	18.2%	18.2%	72.7%	9.1%
PGY2 (n = 12)	54.5%	45.5%		83.3%	16.7%	16.7%	66.7%	16.7%
PGY3 (n = 18)	44.4%	55.6%		77.8%	22.2%	11.1%	66.7%	22.2%
PGY4 (n = 17)	41.2%	58.8%		88.2%	11.8%	5.9%	70.6%	23.5%
PGY5 (n = 17)	47.1%	52.9%		88.2%	11.8%	5.9%	70.6%	23.5%
PGY6 (n = 15)	53.3%	46.7%	6.7%	80.0%	13.3%		73.3%	26.7%
Total (n = 90)	47.2%	52.8%	1.1%	83.3%	15.6%	8.9%	72.2%	18.9%

*Percentage (%) of participants who identify within each demographic category.

differences were found when MSK30 data were organized by participating physician's clinical confidence ($p \leq 0.05$), and clinical confidence was not a predictor of success on the examination ($r = 0.06$). However, the 33.3% of postgraduate physicians who completed optional MSK-related electives (e.g., sports medicine, orthopaedics, and physical medicine and rehabilitation) during their clerkship training performed significantly better on the MSK30 when compared with those who completed only the program's mandatory 2 weeks of MSK training during clerkship ($p \leq 0.01$) (Fig. 4). Despite this, there was little correlation between MSK elective participation and performance on the MSK30 ($r = 0.29$), suggesting that MSK elective courses during clerkship training were not a predictor of success on the examination. Interestingly, postgraduate physicians who practice

in MSK-related fields (e.g., orthopaedics, physical medicine and rehabilitation, and sports medicine) performed significantly better on the examination when compared with family physicians ($p \leq 0.01$) (Fig. 5).

Discussion

MSK injuries and diseases represent a significant portion of a physician's daily practice²; yet, historically, MSK training across nationally accredited medical programs has been found to represent only a small fraction of curricular time^{3,14,19,20}. As a result, previous research has illustrated that many physicians lack adequate MSK knowledge, confidence, and clinical skills^{3-7,16}. This investigation relied on methodologies that had been previously used to study MSK knowledge

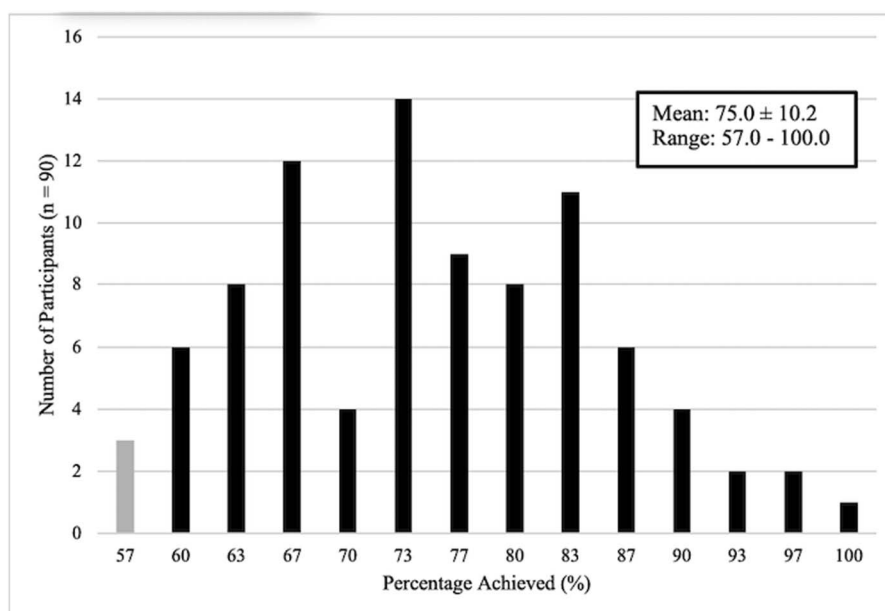


Fig. 2 MSK30 examination score distribution for postgraduate physicians range of MSK30 examination scores achieved by postgraduate physicians (PGY1-PGY6). Gray bar indicates a failing score below 60%. MSK = musculoskeletal.

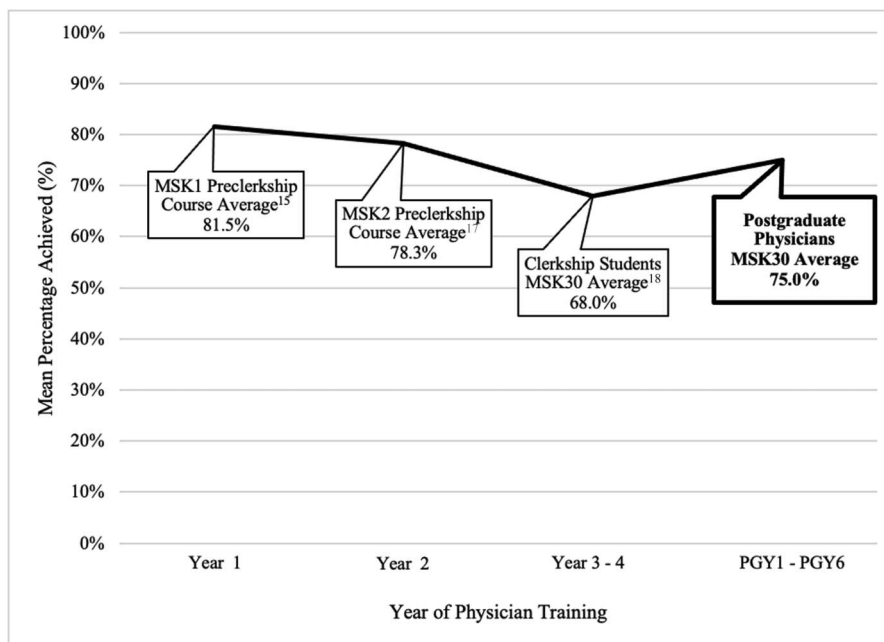


Fig. 3

MSK learning and knowledge retention over the course of a physician's training. Average course and MSK30 scores for the same physician cohorts as they progress through medical school and postgraduate training. Data illustrated that the new preclerkship MSK curriculum supported consistently high levels of MSK learning and knowledge retention. MSK = musculoskeletal.

within single cohorts of medical students and/or postgraduate physicians^{4,6,7,9,10}. In addition, the design of this study was unique in that it included postgraduate physician data from 6 consecutive years of graduates from the same medical program, and the postgraduate examination results for each cohort could be directly compared with preclerkship MSK examination data that had been previously reported^{15,17}. Examination scores

observed in this study were higher than previously reported in the literature, and the scores for each cohort were consistent with levels of academic performance observed during preclerkship studies¹⁵. Beyond this, data suggested that MSK30 scores were uninfluenced by factors such as gender, year of graduation, or previous academic performance in medical school. As such, the results of this investigation affirm the

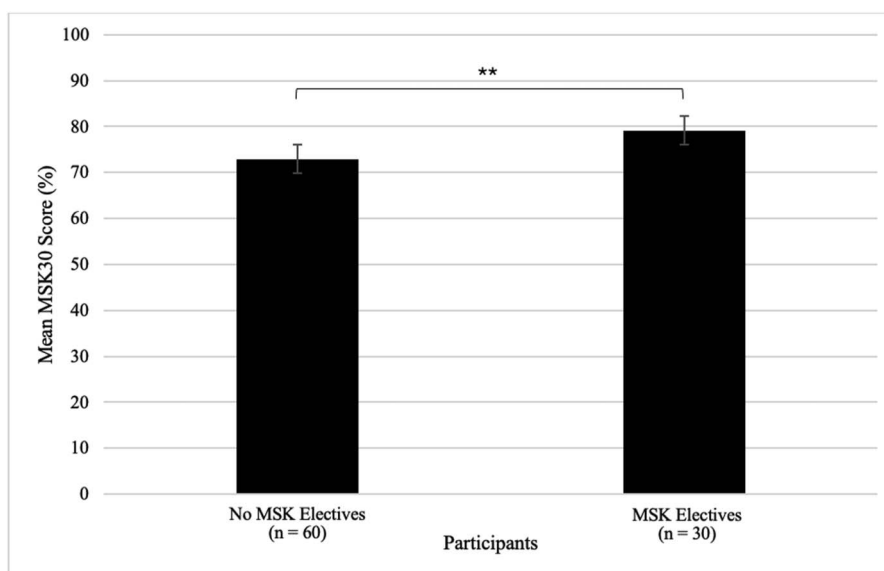


Fig. 4

Impact of elective participation during clerkship on MSK learning and knowledge retention among postgraduate physicians. Additional clinical exposures during clerkship training significantly enhance MSK learning and knowledge retention (** $p \leq 0.01$).

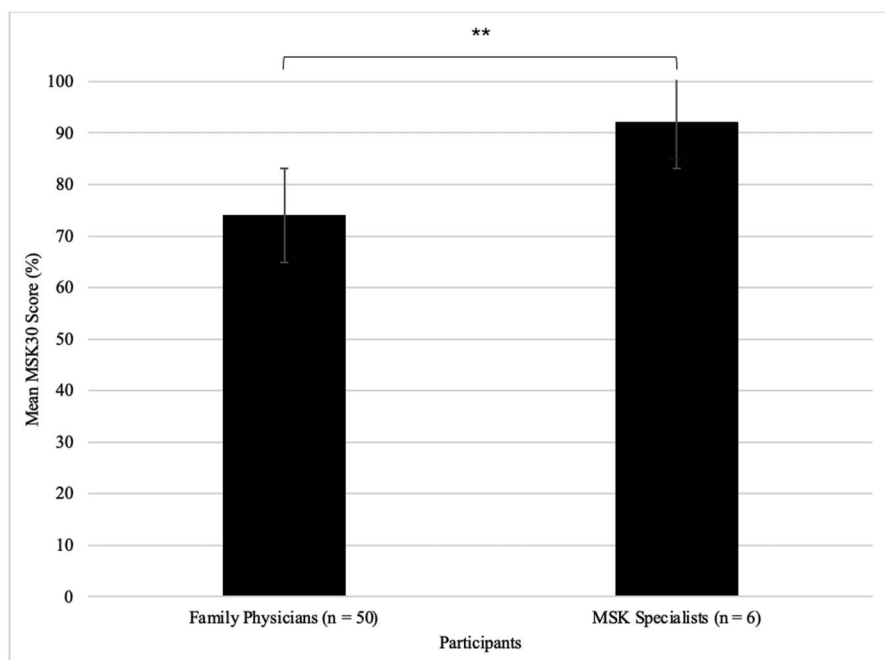


Fig. 5

A comparison of MSK learning and knowledge retention across different areas of medicine family physicians retain significantly less MSK knowledge than MSK specialists on core or must-know topics in MSK medicine (** $p \leq 0.01$). MSK = musculoskeletal.

hypothesis that the program's new preclerkship curriculum supports high levels of MSK learning and knowledge retention among its postgraduate physicians.

The survey was completed by a total of 90 postgraduate physicians from the medical program with a response rate representative of 1 in every 6 physicians who completed the new curriculum. This response rate was similar to that observed in previous investigations of postgraduate physicians^{9,11}. Participants were representative of a diverse group of doctors across gender, age, and SES (Table II) and are consistent with data previously published for nationally accredited medical programs in both Canada and the United States^{21,22}. In addition, the study sample included representation from a vast array of medical specialties including family physicians (56.5%), MSK specialists (e.g., physical medicine and rehabilitation; orthopaedics—7.1%), and other specialty fields (e.g., cardiology, diagnostic radiology, general surgery, neurology, and internal medicine—36.5%), and this distribution was representative of that observed across practicing physicians in Canada²³.

Physicians who had completed the program's new preclerkship curriculum displayed higher levels of MSK learning and knowledge retention (Fig. 2) than has been previously reported in the literature^{8,10,11}, with only a very small percentage of physicians failing to obtain a passing grade (<60.0%) on the MSK30. Examination performance was consistent across all 6 years of postgraduate physicians (PGY1-PGY6) and results did not significantly differ across demographic variables (e.g., gender, age, and SES). These results are in alignment with our findings from previous research, which involved the same cohorts during preclerkship training, and indicated that the

new preclerkship curriculum supported high levels of learning and knowledge acquisition^{15,17}. The current results are likely attributable to a host of factors. First, the program's new preclerkship curriculum was reflective of many of the current pedagogical trends that are being observed within revised medical curricula around the world^{12,13,24,25}. The curriculum used a consistent, evidence-based approach to deliver a stand-alone curriculum that focused on core or must-know topics in MSK medicine. Despite previous research which indicated that nationally accredited medical programs lack consistency in the topics that are covered in preclerkship MSK curricula (only 25.0% of core or must-know topics are reliably covered)^{12,13}, this program's new preclerkship curriculum “covered” or “covered in detail” 15 of 16 (93.8%) MSK topics^{11-14,23,26}. Second, previous investigations have highlighted that many accredited medical programs dedicate only a very small amount of curricular time (>3.0%) to MSK instruction^{14,20,26}. In contrast, this program's MSK curriculum represented approximately 12.0% of the total preclerkship time dedicated to Health and Disease education, with only one topic (neuroscience) having more instructional time during preclerkship training. Interestingly, the total curricular time that this program dedicated to MSK learning closely aligned with the curricular averages recently reported for accredited medical programs within both Canada¹² and the United States¹³ (Table I). Finally, the program's new preclerkship curriculum provided students with consistent and complimentary learning opportunities using an interdisciplinary and multimodal approach to curriculum delivery. Previous research clearly indicated that student engagement and knowledge can be enhanced through the use of a multimodal approach to

teaching and learning²⁷ and an interdisciplinary learning environment involving a variety of different physician types (i.e., orthopaedics, rheumatology, physical medicine and rehabilitation, radiology, sports medicine, and family medicine)^{4,12,13,28,29}.

Data also indicated that respondents who practiced in the area of family medicine displayed higher levels of MSK learning and knowledge than previously reported⁹. However, family physicians performed significantly worse on the MSK30 examination when compared with MSK specialists. This suggests that there continues to be a need for the advancement and expansion of MSK education provided to family physicians during their residency training to ensure that they are adequately prepared for clinical practice within the Canadian Medical system as the “first line of defense” for patients seeking MSK care³⁰.

Physicians who completed optional electives in MSK-related fields (e.g., orthopaedics, physical medicine and rehabilitation, and sports medicine) during clerkship training also performed significantly better on the MSK30. Elective exposures ranged from 1 to 12 weeks in duration, with some participants indicating that they completed additional electives during their residency training. These results are consistent with previous research which demonstrated that additional clinical exposures during clerkship training are associated with higher levels of MSK knowledge¹³. Enhanced MSK knowledge through additional training mimics previous research, which indicated that spaced learning decreases the effect of forgetting and increases learning and knowledge retention over the long term²⁵. It is recommended that accreditation bodies (e.g., AFMC and AAMC) provide additional MSK learning opportunities to improve postgraduate physician's MSK knowledge, confidence, and clinical skills.

Limitations

This study is not without limitations. Previous studies have used the “Basic Competency Examination in MSK Medicine” to evaluate learning and knowledge retention among postgraduate physicians¹¹. This 25-question, open-ended examination has several weaknesses, and as such, the current study chose to use the “MSK30”¹⁶. The MSK30 is a recently standardized and validated examination that is believed to more accurately reflect the multiple-choice testing style that is used within the preclerkship curricula of a majority of AFMC- and AAMC-accredited medical programs^{12,13}. Second, because this investigation used an online platform to administer the MSK30, it is possible that respondents could have accessed external resources to answer questions. However, a post-hoc analysis of time-to-completion and MSK30 data indicated that scores were not significantly influenced by a respondent's completion time ($p \geq 0.05$).

Third, institutional privacy restrictions prevented the investigators from accessing data that would have facilitated direct comparison of respondent's academic performance in preclerkship courses with their MSK30 score. Instead, respondents were asked to self-report their preclerkship MSK grades, and it must be acknowledged that the accuracy of self-reported data can be influenced by a host of factors. Fourth, a review of this program's clerkship curriculum and an evaluation of clerkship student's MSK learning and knowledge retention were beyond the scope of the current investigation. As such, it is possible that postgraduate levels of MSK learning and knowledge retention observed within the PGY1 to PGY6 cohorts were influenced (positively or negatively) by learning and experiences that took place during the clerkship portion of medical training. Finally, although only 16.0% of eligible participants completed the MSK30 examination, this response rate falls within a normal range previously established in the literature^{31,32} and is similar to that observed in other studies involving physicians^{9,11}. To address this limitation, the investigators plan to complete a future multicenter cross-sectional survey-based investigation that recruits postgraduate physicians from a number of nationally accredited Canadian medical programs with different preclerkship MSK curriculums.

Conclusion

Data confirmed that the program's new preclerkship curriculum supported high levels of long-term MSK knowledge retention among postgraduate physicians and illustrated the importance of MSK exposure during clerkship and residency training for enhancing long-term knowledge retention about MSK topics. It is hoped that the results of this investigation advance the current body of knowledge dedicated to improving physician learning and knowledge retention and provide curricular evidence that can be used by other nationally accredited medical programs to enhance physician learning and knowledge in the area of MSK medicine. ■

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