Received: 31 July 2022 | Revised: 7 February 2023 | Accepted: 8 February 2023

DOI: 10.1111/medu.15033

RESEARCH ARTICLE

MEDICAL EDUCATION IN REVIEW

Athletes in medicine: A systematic review of performance of athletes in medicine

Kathryn G. Anderson[1] | Jacie Lemos[2] | Samantha Pickell[3] | Christopher Stave[1] | Michael Sgroi[1]

[1]Stanford University School of Medicine, Stanford, California, USA

[2]University of Michigan Medical School, Ann Arbor, Michigan, USA

[3]Department of Human Biology, Stanford University, Stanford, California, USA

Correspondence
Michael Sgroi, Department of Vascular Surgery, Stanford University, 780 Welch Rd, CJ350, Palo Alto, CA, USA.
Email: msgroi@stanford.edu

Funding information
None.

Abstract

Introduction: As interest in medicine grows, admissions committees must review an increasingly competitive pool of medical school and residency candidates. Nearly all admissions committees have moved towards a holistic review, which considers an applicant's experiences and attributes in addition to academic metrics. As such, identifying nonacademic predictors of success in medicine is necessary. Parallels between skills necessary to succeed in athletics and in medicine have been drawn, including teamwork, discipline and resiliency. This systematic review synthesises the current literature to evaluate the relationship between participation in athletics and performance in medicine.

Methods: The authors searched five databases to conduct a systematic review following PRISMA guidelines. Included studies assessed medical students, residents or attending physicians in the United States or Canada and used prior athletic participation as a predictor or explanatory variable. The review examined associations between prior athletic participation and outcomes in medical school, residency and/or as an attending physician.

Results: Eighteen studies evaluating medical students (78%), residents (28%) or attending physicians (6%) met inclusion criteria for this systematic review. Twelve (67%) studies specifically assessed participants based on skill level, and five (28%) studies specifically assessed participants based on type of athletic participation (team versus individual). Sixteen studies (89%) found that former athletes performed significantly better than their counterparts ($p < 0.05$). These studies found significant associations between prior athletic participation and better outcomes in multiple performance indicators, including exam scores, faculty ratings, surgical errors and burnout.

Conclusions: Current literature, although limited, suggests that prior participation in athletics may be a predictor of success in medical school and residency. This was demonstrated through objective scoring methods, such as USMLE, and subjective outcomes, such as faculty ratings and burnout. Specifically, multiple studies indicate that former athletes demonstrated increased surgical skill proficiency and decreased burnout as medical students and residents.

Kathryn Anderson and Jacie Lemos contributed equally to this work.

1 | INTRODUCTION

Interest in the medical profession has been steadily growing in recent years. From the 2002 to 2020 admissions cycles, the number of applicants to medical school increased by over 50%.[1] As interest in the medical profession grows, admissions committees and stakeholders are tasked with reviewing an increasingly competitive pool of candidates to identify those best suited for medical school, residency programmes and a career beyond medical education. Medical school and residency applications include standardised objective measures, such as undergraduate GPA, the Medical College Admission Test (MCAT) or the United Stated Medical Licensing Examination (USMLE), as well as a more holistic review of experiences, extracurriculars and personal attributes. A vast amount of research in the admissions literature has shown a correlation between quantitative academic measures and future success in medical school.[2–5] While admissions committees traditionally have placed greater emphasis on these quantitative academic measures, a holistic review has been shown to confer benefits such as increased diversity of matriculants.[6,7] As such, in recent years the Association of American Medical College has encouraged medical schools to use a holistic review, which they define as a "selection process which takes into consideration applicants' experiences, attributes, and academic metrics as well as the value an applicant would contribute to learning, practice, and teaching." According to the AAMC, nearly all medical schools in the United States now report using some elements of holistic review.[8] In addition to an increased adoption of holistic reviews, the COVID-19 pandemic led to several changes in university grading options, MCAT postponements and cancellations, and limited research and clinical opportunities. These disruptions have likely forced admissions committees to rely even more heavily on alternative predictors of success in medicine. Despite this increasing shift to holistic review that considers applicant experiences, many qualitative associations between non-academic experiences, including prior participation in athletics, and performance in medical school have yet to be fully established.

The holistic review framework is expanding beyond medical school admissions and is now being applied for applicant selection at many residency programmes and medical school faculty positions.[9] Furthermore, the USMLE Step 1 exam changed from a numerical score to pass-fail scoring in January 2022. Traditionally, this exam has carried significant weight in the residency admissions process. While we have yet to see how this change will affect residency programmes, new predictors of success in residency will need to be established. To assess important skills and traits, residency applicant experiences will likely be considered more heavily in the admissions process. As such, understanding the relationship between prior participation in athletics and performance as a resident or attending physician may be beneficial.

Although the literature is limited, studies have drawn parallels between the skills necessary to compete in high-level athletics and those necessary to succeed in the path to becoming a physician. These associations may come from the similar qualities that determine success in both athletics and a career in medicine. The highest performing medical students, residents and attending physicians adapt easily, work well in team settings, respond well to criticism, are self-disciplined and manage their time well. Performing as a high-level athlete also requires many of these qualities and may therefore provide advantageous preparation for the rigour of medical school and residency.[10,11] Previous literature has also found that former athletes experience less burnout, make more time for leisure during medical school and may view their medical education as more collaborative and supportive of their autonomy compared to their non-athlete peers.[12,13] Due to these parallels, some medical schools already consider participation in athletics when reviewing medical school applications. For example, the written secondary application for some medical schools includes a portion that asks students whether they have participated in athletics during college and, if so, to specify whether it was at the varsity or club level.

Considerable research details the transferability of athletic skills to the workforce in fields aside from medicine. Employers in these fields may favour applicants who played sports if candidates learned skills such as teamwork, resilience, discipline and more. Particularly regarding leadership, a highly important skill, one study demonstrated that athletes outscored non-athlete peers on measures such as leadership ability,[14] while another demonstrated that men who had participated in varsity-level sports ultimately showed higher levels of leadership within the workplace.[15] Likewise, a study in 2015 by ESPNW discovered that 80% of female Fortune 500 executives played competitive sports at some point in their lives.[16] Given the importance of leadership and other aforementioned traits in medicine, a correlation between prior athletic experience and success in medicine may exist.

Despite the growing need for medical school admissions committees to identify predictors of success in medicine, a systematic review of the current literature on the relationship between participation in athletics and success in medical school, residency and as a physician has yet to be performed. By further exploring this relationship in the current literature, the present systematic review aims to answer the question of whether participation in athletics is a good predictor of success in medical education and beyond. In doing so, this study seeks to better inform medical education institutions, admissions committees, applicants and other stakeholders of the extent to which participation in athletics could be considered while reviewing a candidate's potential for success in medicine.

2 | METHODS

A data search protocol was developed per PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guidelines.[17] We performed a comprehensive search of online databases on 9 February 2021 using the search engines PubMed, EMBASE, Web of Science, ERIC and Google Scholar. The following query was used for the search:

(success* OR perform* OR predict* OR "clinical competence") AND (residency* OR resident* OR "graduate medical education" OR interns OR internship OR "medical student*" OR "clinical fellow*") AND (sports OR sport OR athlete* OR olympic*) NOT "sports medicine"

The syntax of the database determined the format of the search terms. No limitations on date range were implemented. Subsequently, reference review was performed on each qualifying article to uncover relevant literature that did not populate in the primary search.

2.1 | Eligibility criteria

To be included in this review, a study had to meet the following criteria: (1) Quantitatively assessed medical students, residents or attending physicians, (2) used prior participation in athletics as a predictor or explanatory variable, (3) peer-reviewed full-text available in English and (4) assessed a population in the United States or Canada. Studies were limited to the United States and Canada because both U.S. and Canadian medical schools follow the Medical School Admissions Requirements (MSAR), both countries typically require students to complete a similar path prior to obtaining medical licensure (i.e. earn a bachelor's degree, attend and complete medical school and then complete a medical residency), and both U.S. and Canadian medical schools have low average acceptance rates (7% and 5.5% in 2020, respectively).[18] We excluded references that contained only unpublished data and references that used activity level as a predictor rather than participation in athletics. All references were screened by at least two reviewers (JL, KA or SP). Another reviewer (MS) was consulted in cases of disagreement, which were resolved through consensus and agreement among all reviewers.

2.2 | Quality analysis

Two independent reviewers (JL, SP) used the Newcastle-Ottawa Scale (NOS) for case–control and cohort studies to assess the quality of each study.[19] The NOS has three domains based on the selection of participants, comparability of the groups, and quality of the outcomes. Quality scores range from 0 to 10 points for cross-sectional studies (adapted NOS scale as previously utilized[20]) and 0 to 9 points for cohort studies, with higher scores indicating higher-quality. Studies were graded as high quality if they achieved a score of ≥7 and low quality if they achieved a score of <7. A kappa value of 0.6 between the 2 independent reviews was calculated, indicating acceptable inter-rater agreement. A third reviewer (KA) was consulted in cases of disagreement, which were resolved through consensus and agreement among all reviewers.

2.3 | Data extraction and analysis

The following data were extracted from included studies into a shared spreadsheet: author, study year, study-design, sample size, target population (i.e. medical students, residents, etc.), the athletic participation level (i.e. collegiate, professional, etc.), method of ascertaining participation level (i.e. self-report, residency application file, etc.), outcomes used to assess performance and the associations detected between athletic participation and performance (with p-values). Included studies were categorically grouped based on their exposure definition and their outcome definition. Exposure categories included (1) assessed participant outcomes based on participants' skill level of athletic participation and (2) assessed participant outcomes based on individual versus team sport involvement. Outcome categories included (1) academic performance in medical school, (2) performance in residency, (3) surgical skills performance and (4) motivation/burnout. The categories were not mutually exclusive. p values were recorded to assess the significance of reported associations. Two reviewers cross-checked all extracted data for accuracy.

3 | RESULTS

As shown in Figure 1, we identified 1044 non-duplicate references for which we reviewed titles, abstracts and/or full texts. Of these, we determined all but 89 studies failed to meet inclusion criteria or met exclusion criteria for this systematic review. Next, we reviewed the full text of these 89 references. Eighteen of these references met inclusion criteria for the systematic review.[10–13,21–33] Of the 18 included studies, 14 (78%) evaluated medical students, five (28%) evaluated residents or residency applicants, and one (6%) evaluated attending physicians. Five (28%) studies specifically assessed prior participation in team sports (versus individual), and 12 (67%) studies specifically assessed participants based on their highest level of athletic participation (i.e. varsity collegiate athletics and professional athletics). Three studies (17%) evaluated medical students in Canada, whereas the remaining 15 studies analysed a population in the United States.

3.1 | Quality assessment

NOS scores for cross-sectional studies ranged from 6 to 10 points. There was one cohort study included, and both raters scored it as 7. Studies were generally high quality with 15 (83%) achieving a score of ≥7 (i.e. high quality). The average NOS score for cross-sectional studies (and standard deviation [SD]) was 7.6 ± 1.2. NOS grades are listed by study in Table 1.

3.2 | Summary of included studies

Out of the 18 studies included, 16 (89%) found that athletes (i.e. participants with prior athletic experience) performed significantly

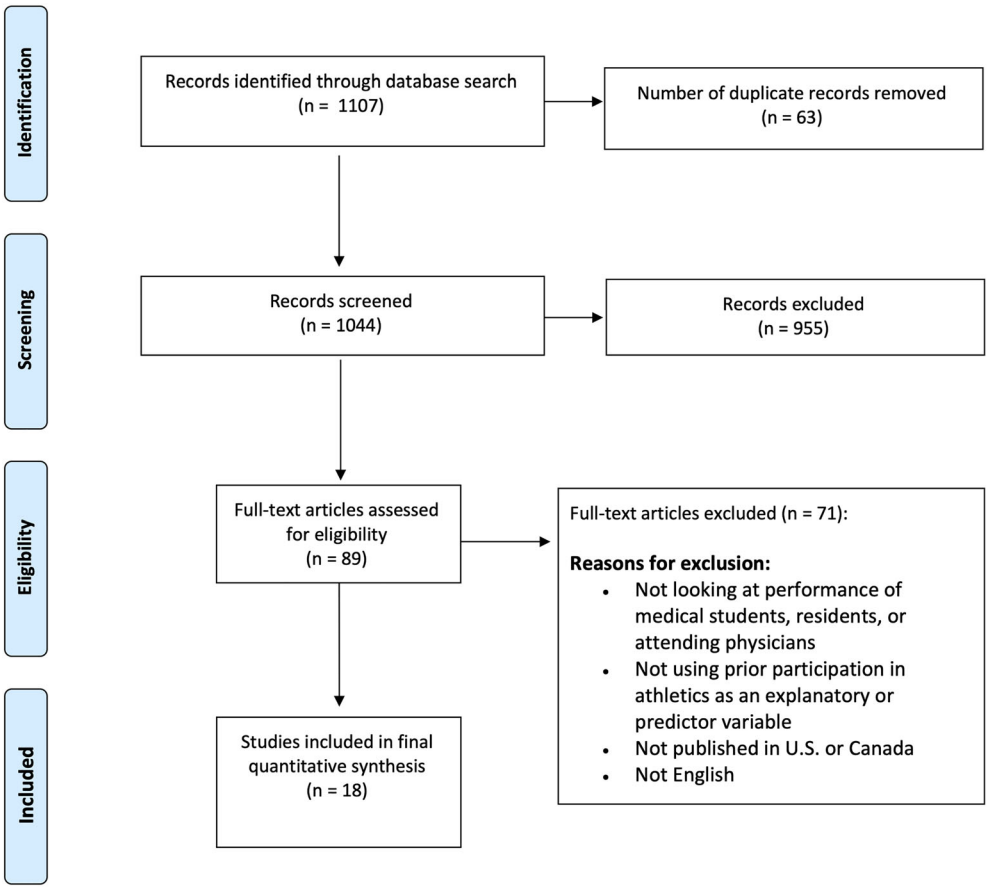

FIGURE 1 Study selection per PRISMA guidelines. [Color figure can be viewed at wileyonlinelibrary.com]

better than their counterparts ($p < 0.05$). One (6%) study found that athletes performed significantly worse than their counterparts, and one study (6%) had inconclusive results (Table 1). The results of included studies are summarised categorically below.

3.3 | Level of prior athletic participation and performance

Twelve (67%) studies specifically assessed participants based on skill level of athletic participation. Eight (44%) used a graded scale (i.e. self-reported highest level of competition with options from no participation to Olympic level competition) and 4 (22%) compared former varsity collegiate athletes to non-varsity collegiate athletes. Seven of the eight studies that stratified participants based on a graded scale found that higher levels of athletic involvement correlated to improved performance metrics in medical school and residency, including decreased burnout, increased likelihood of being selected as a chief resident and surgical performance.[12,13,24,26,29,32,34] One of these (Lodewyk et al.) found that this graded response only occurred in team sport athletes (versus individual). One study was inconclusive on the impact of level of athletic participation on structured clinical exam scores.[23]

All four studies that specifically compared former varsity athletes to non-varsity athletes found that participation in prior varsity athletics was associated with significantly higher outcomes ($p < 0.05$) in performance metrics in both medical school and residency, including higher levels of grit and fewer unsatisfactory outcomes in surgical residency.

Overall, these studies indicate that performance in medicine increases with higher levels of athletic performance. This level-dependent response suggests participation in high-level athletics may be a strong predictor of success in medicine.

3.4 | Type of prior athletic participation and performance

Five (28%) studies specifically assessed a history of participation in team sports versus no history of participation in team sports. Of these, three articles had outcomes favouring prior participation in team sports. These studies found that students with a history of participating in team sports felt more connected to others during medical school, had higher faculty ratings in an otolaryngology residency programme and had fewer unsatisfactory outcomes in a surgical residency programme.[13,24,30] One study found that those with a history of individual sports had higher levels of tolerance to ambiguity and uncertainty in medical school (over both no history of sports and a history of team sports),[34] and one study had outcomes favouring no history of team sports, reporting that medical students with a history

TABLE 1 Summary of included studies.

Author	Year	Study design	Sample size	Study population	Measure of athletic participation	Outcome category	Relevant conclusion(s)	p < 0.05? (Y/N)	NOS grade	Performance of athletes compared to non-athletes
Academic medical school performance										
Breitkopf	2016	Prospective	104	Medical students	Prior participation in team sport (y/n).	Academic Medical School Performance	Applicants with prior experience playing team sports scored lower on standardised behavioural interviews than those with no experience in team sports.	y	High	Decreased
Chan	2015	Cross-sectional	265	Medical students	Coded from no record of sports to national-level competition.	Academic Medical School Performance	No relationship was identified between participation in sport and objective structured clinical examination scores.	n	High	Inconclusive
Strowd	2019	Retrospective Review	441	Medical students	Varsity collegiate sports (y/n).	Academic Medical School Performance	Medical students with experience as a varsity collegiate athlete outperform their peers on several metrics in both standardised tests and clinical clerkships.	y	High	Increased
Residency performance										
Chole	2012	Retrospective Review	46	Medical students	Scale from 0 (no experience) to 2 (established excellence in team sport).	Residency Performance	Excellence in athletics, specifically a team sport, is positively correlated with faculty ratings.	y	High	Increased
Claessan	2019	Retrospective Review	119	Orthopaedic residents	Former Olympic or varsity level (y/n).	Residency Performance	Experience with Olympic or varsity athletics was associated with a better residency performance score.	y	High	Increased
Hayden	2005	Retrospective Review	54	Emergency medicine residents	Distinctive factors (y/n); e.g. championship-level athlete.	Residency Performance	Distinctive factors, including competing as a championship-level athlete, was a predictor of overall performance in emergency medicine residency.	y	High	Increased

(Continues)

TABLE 1 (Continued)

Author	Year	Study design	Sample size	Study population	Measure of athletic participation	Outcome category	Relevant conclusion(s)	p < 0.05? (Y/N)	NOS grade	Performance of athletes compared to non-athletes
Maxfield	2020	Retrospective Review	157	Residency applicants	Involvement of sports: none, recreational, college or elite, or national collegiate athletic association (NCAA) Division I level.	Residency Performance	Residents with more intensive sports participation were more likely to be selected as chief residents.	y	High	Increased
Naylor	2008	Retrospective Review	111	Surgery residents	Participation in team sports (y/n).	Residency Performance	Residents who played team sports in college or medical school had significantly fewer unsatisfactory outcomes compared to those who did not.	y	High	Increased
Surgical skills performance										
Cychosz	2019	Prospective	43	Medical students	Regularly participated in a sport involving hand-eye coordination (y/n) versus no hand-eye coordination (y/n).	Surgical Skills Performance	Individuals who had regularly participated in sports requiring hand eye coordination saw greater improvement in arthroscopic performance, specifically time and camera path length.	y	High	Increased
Harbison	2017	Cross-sectional	33	Medical students, residents, and attending physicians	History of sports participation (y/n).	Surgical Skills Performance	There was an association between increasing levels of sports participation and endoscopic sinus surgery global rating scale score.	y	High	Increased
Harper	2007	Experimental	242	Medical students	Sports participation for at least 4 years (y/n).	Surgical Skills Performance	Participants at least 4 years of experience in sports made fewer mechanical errors, broke fewer sutures and committed fewer total errors during robotic suturing.	y	High	Increased

TABLE 1 (Continued)

Author	Year	Study design	Sample size	Study population	Measure of athletic participation	Outcome category	Relevant conclusion(s)	$p < 0.05$? (Y/N)	NOS grade	Performance of athletes compared to non-athletes
Richey	2020	Prospective	49	Medical students	Current participating in sports (y/n).	Surgical Skills Performance	High levels of athletic experience were significantly associated with improved performance and increased likelihood of achieving competence on an arthroscopic surgical simulator.	y	High	Increased
Shee	2016	Prospective	30	Medical students	Experience level of athletics on a scale of 0 (no experience) to (4) varsity level.	Surgical Skills Performance	There was a positive correlation between athletic skill level and initial performance on two robotic surgery simulator tasks. This did not persist after the third repetition of the task.	y	High	Increased
Zeng	2010	Prospective	65	Medical students	Highest level of competition: none, recreational, high school, college or professional.	Surgical Skills Performance	Researchers found a relationship between athletic experience and performance on pre-course suturing and 1-handed knot tying.	y	Low	Increased
Burnout & motivation										
Babenko	2017	Cross-sectional	267	Medical students	Highest level of competition on a scale of 1 (none) to 6 (international competition).	Burnout/ Motivation	Level of involvement in athletics was negatively correlated with academic burnout and maladaptive learning achievement goals.	y	Low	Increased

(Continues)

TABLE 1 (Continued)

Author	Year	Study design	Sample size	Study population	Measure of athletic participation	Outcome category	Relevant conclusion(s)	p < 0.05? (Y/N)	NOS grade	Performance of athletes compared to non-athletes
Babenko	2020	Cross-sectional	200	Medical students	Longest participation type: none; team sport; and individual sport; Highest level of involvement: 1 (recreational non-competitive) to 7 (international competition).	Burnout/ Motivation	Students with prior background in team sports were more satisfied with the level of relatedness during medical school. There was a positive correlation between level of sport involvement and satisfaction with the autonomy and the amount of leisure-time exercise they participated in during medical school.	y	Low	Increased
Camp	2019	Cross-sectional	455	Medical students	Varsity collegiate sports (y/n).	Burnout/ Motivation	Former collegiate athletes demonstrated greater grit, consistency of interest, perseverance and self-control.	y	High	Increased
Lodewyk	2020	Cross-sectional	61	Medical students	Prior participation in sport: 0-none; 1-team sport; 2-individual sport	Burnout/ Motivation	The observed findings support the importance of extracurricular activities, particularly individual and higher level team sport, in developing tolerance of ambiguity and uncertainty (in medical school).	y	High	Increased

Note: Grey: favours prior participation in athletics on improved performance metric, white: inconclusive or favours no prior participation in athletics on improved performance metric.

of team sports scored lower on standardised obstetrics and gynaecology residency interviews.[21]

3.5 | Academic performance in medical school

Three (17%) of the included studies evaluated academic performance in medical school. A retrospective review of 441 medical students found that, while MCAT scores did not differ between former collegiate athletes and their counterparts ($p = 0.62$), athletes scored significantly higher ($p < 0.05$) on the USMLE step 1 exam, the NBME year 3 shelf exam and the USMLE step 2 exam. In year 3 clinical clerkships, athletes performed significantly better ($p < 0.05$) on clinical scores, average number of honours, average year 3 score and Alpha Omega Alpha (AOA) status. No difference was found between athlete and non-athlete Gold Humanism Award status ($p = 0.52$). The authors concluded that medical students with experience as a varsity collegiate athlete outperform their peers in both standardised tests during medical school and clinical clerkships.[11] In contrast, a prospective study of 104 medical students applying to an obstetrics-gynaecology residency programme found that applicants with prior experience playing team sports scored lower on the standardised behavioural interviews than those with no experience with team sports ($p = 0.02$).[21] Another study in 2015, which assessed 265 medical students, found no significant relationship between prior participation in sport and objective structured clinical examination (OSCE) results.[23] Together, these articles demonstrate inconclusive results on the relationship between prior athletic experience and academic performance in medical school.

3.6 | Performance in residency

Five (28%) studies evaluated the relationship between prior athletic experience and performance in residency. A retrospective review of 46 graduates from an otolaryngology residency programme found a significant, positive correlation between participation in a team sport and faculty rating score ($R^2 = 0.32$, $p < 0.001$). USMLE score, AOA status, percentage of honours in clinical rotations, letters of recommendation and experience as an acting intern showed no significant correlation with clinical faculty ratings, while interview score and medical school rank showed a weak positive correlation ($R^2 = 0.1$, $p = 0.04$ and $R^2 = 0.18$, $p = 0.03$)[24] Similarly, a retrospective review of 119 orthopaedic residents found that prior participation as an Olympic or varsity athlete was associated with a higher subjective residency performance score ($p = 0.018$).[10] Another study found that while medical school attended was one of the strongest and most consistent predictors of success in emergency medicine residency graduates, having "distinctive factors," which included competing as a championship-level athlete, was a significant predictor of overall performance in residency ($p < 0.05$).[28] In a retrospective review of 157 applications for a radiology residency programme, it was found that residents with sports participation were significantly more likely to be chief residents ($p = 0.04$).[29] Finally, a retrospective review of 111 surgical residents found that residents who played team sports in college had significantly fewer unsatisfactory outcomes such as attrition from residency programme or failure to pass the American Board of Surgery examinations compared to those who did not ($p = 0.02$).[30]

All five studies evaluating the relationship between prior athletic experience and performance in residency concluded that prior participation in athletics was a significant predictor of success on various metrics during medical residency.

3.7 | Surgical skills performance

Six (33%) studies evaluated the relationship between prior athletic experience and surgical skills performance.

A 2019 study evaluating 43 medical students found that while general sports participation was not correlated with initial arthroscopic performance, participants who reported they had regularly participated in sports requiring hand-eye coordination demonstrated significant improvement in performance time (182 versus 78 seconds, $p = 0.025$) compared with those who were not involved in sports.[25] Additionally, in an assessment of 12 medical students, nine residents and five attending otolaryngologists, researchers found a significant association between increasing levels of sports participation and endoscopic sinus surgery global rating scale score ($p = 0.033$).[26] Zeng et al. evaluated 65 fourth-year medical students and found a statistically significant relationship between athletic experience and performance on suturing tasks ($p = 0.048$) and one-handed knot tying ($p = 0.042$).[33] In a prospective study of 242 medical students, researchers found that participants who played sports for at least 4 years made significantly fewer mechanical errors ($p = 0.04$), broke fewer sutures ($p = 0.01$) and committed fewer total errors ($p = 0.01$) compared with others.[27] Another 2016 study assessed 30 medical students on their performance on a robotic surgery simulator, and found a significant positive correlation between previous athletic skill level and performance on task 1 ($p = 0.0002$) and task 2 ($p = 0.009$). This association did not persist after the third repetition of the task. Musical instrument or video game skill level was not significantly correlated with performance.[32] Finally, a study in 2020 assessed 49 medical students and found participants with high levels of athletic experience were significantly more likely to achieve competence on an arthroscopic surgical simulator ($p = 0.006$), as well as have an improved performance on the arthroscopic surgical simulator ($p = 0.008$).[31]

All six studies evaluating the relationship between prior athletic experience and surgical skills performance found that individuals with prior experience in athletics significantly outperform those with no athletic experience in some aspect of surgical skills performance. Hand-eye coordination was suggested in many of the articles as a potential moderator of this relationship, as hand-eye coordination is needed for many sports as well as surgical skills.

3.8 | Burnout and motivation

Four studies (22%) evaluated the relationship between prior athletic experience and burnout/motivation metrics. A cross-sectional study of 267 medical students found that students with higher levels of past sport involvement were found to have lower levels of burnout ($r = -0.15$, $p = 0.014$). These researchers also found significant negative correlations ($p \leq 0.001$) between level of involvement in sport and psychological approaches that focus on others' perception of them (e.g. "I enjoy when others in my program are aware of how well I am doing"; $r = -0.20$, $p < 0.001$).[12] Similarly, a survey of 200 medical students at a Canadian university found that students with prior background in team sports were significantly more satisfied with the level of relatedness, or connection to others, during medical school ($p < 0.05$). There was also a significant positive correlation between level of sport involvement and satisfaction with autonomy in medical school ($p = 0.041$) and amount of leisure-time exercise during medical school ($p < 0.001$).[13] A cross-sectional survey of 61 third-year medical students found that students with a history of individual sports had a higher tolerance for ambiguity and uncertainty in medical school compared to those without a history of sports ($p < 0.05$). Finally, a 2019 cross-sectional study on 455 orthopaedic surgery residency applicants revealed that former collegiate athletes demonstrated more grit ($p < 0.001$), consistency of interest ($p = 0.007$), perseverance ($p = 0.006$) and self-control ($p = 0.019$) than their non-collegiate athlete peers.[22]

All four studies that assessed burnout/motivation suggest prior participation in athletics significantly improves non-academic indicators of success in medicine such as increased intrinsic motivation and decreased burnout.

4 | DISCUSSION

In this systematic review, we identified 18 peer-reviewed studies that assessed the relationship between prior participation in athletics and medical performance (i.e. performance in medical school, residency or on specific medical tasks such as knot-tying). Out of the 18 studies reviewed, the majority (89%) found that participants with prior athletic experience performed significantly better than their counterparts ($p < 0.05$). This relationship was observed on objective scoring methods, such as USMLE Step 1 score and surgical skill proficiency scores, as well as less on objective subjective measures, such as faculty ratings and burnout. Notably, all four studies that assessed the association between prior athletic experience and burnout/motivation in medical students and residents found that former athletes experienced higher levels of intrinsic motivation and decreased burnout. Additionally, all six studies evaluating the relationship between prior athletic experience and surgical skills performance found that individuals with prior experience in athletics significantly outperform those with no athletic experience in some aspect of surgical skills performance. As interest continues to grow in the medical profession, these findings suggest it may be important for both admissions committees and prospective applicants take athletic participation into account while making decisions.

As physician burnout continues to rise across the country, finding ways to reduce burnout is critical. A history of athletics may be one way to offset this increase. This is consistent with previous findings,[12,13] and suggests that physicians-in-training with prior athletic experience may have additional coping strategies that have a protective effect against burnout. Currently between 25% and 60% of physicians report experiencing burnout, and the stressors leading to burnout are only growing.[35–38] It is important to assess what traits and experiences may help students cope with the challenging medical education process. Educational institutions should continue to encourage prospective medical school applicants to pursue experiences and interests outside of school, such as athletics, so that they can develop effective coping strategies and outlets and therefore minimise burnout.

Standardised test scores and other quantifiable measures of academic success have served as staple criteria for assessing aspiring physicians.[6] However, less objective skills such as the ability to interact well with people, ability to work on a team, time management and resilience are known critical indicators of success in medicine. As demonstrated by many studies, athletes who presumably encompass many of these traits have gone on to succeed in various levels of the medical process from standardised tests and surgical skills to overall success in medical school and residency.[10,11,22,24–26] As standardised tests continue to change to pass/fail, admissions committees should further consider these "special skills" that athletes possess, potentially along with other students engaged in similarly beneficial activities, when assessing candidates during the medical education process.

Holistic admissions criteria which focuses on the attributes and experiences of applicants in addition to objective academic metrics has been shown to result in a more diverse interview pool and matriculant pool than criteria that focus primarily on academic metrics.[39,40] Considering factors that can increase diversity in medicine remains critical. Decades of effort to improve diversity within medical school has made progress with demographics such as Black women, but other groups such as Black men have remained relatively unchanged since 1978.[41] In contrast to medicine, Black men are relatively well represented in college athletics. Black men represent 2.4% of undergraduate students at 65 universities in the top five athletic conferences, yet comprise more than half of the football and basketball teams.[42] Thus, supporting athletes interested in medicine could potentially lead to increased diversity in medical school. For example, many historically Black universities have very strong Division II sports teams as well as schools of medicine.[43] Efforts to connect interested athletes participating on these sports teams with the resources at their schools of medicine could provide one avenue for encouraging student-athletes interested in medicine.

Admissions committees also should consider that many sports require tremendous funding and financial resources at the elite level, even before entrance to college. This can decrease accessibility of students at various income levels. Placing excessive emphasis on high performance athletics without looking at income levels and other demographic factors in tandem could therefore unfairly advantage

applicants with more financially privileged backgrounds. Simultaneously, however, approximately 86% of college athletes live below the poverty line.[44] Given the large proportion of student athletes experiencing financial hardship, further research is necessary to explore ways to support these student athletes while also weighing how athletics may advantage some high-income individuals. Admissions committees should consider these factors holistically when weighing the benefits of athletic participation alongside other qualitative pre-matriculation data.

While the majority of the studies included in this review favoured a history of participation in athletics on performance in medicine, 2 (11%) included studies did not report outcomes favouring prior participation in athletics. Breitkopf et al. found that medical students with a history of team sports scored lower on standardised obstetrics and gynaecology residency interviews. This paper also found that prior work experience was a predictor of success for interview scores.[21] Chan et al. found no benefit to prior athletic participation on performance in medical students' first objective structured clinical examination (OSCE), but given the low sample size of the subgroup, considered the results inconclusive.[23] This paper also assessed for a history of verbal public performance (i.e. public speaking in student council and debate) and reported improved OSCE scores in those with a history of verbal public performance. Both studies assessed participants' ability to perform in professional, standardised settings. As college athletes are often discouraged or limited in their ability to participate in internships or extra-curricular professional opportunities, it may be more difficult for them to grow the professional skillset needed to exceed in tasks such as standardised interviews. Future research should assess for potential professional competencies that athletes may be missing, with the goal of informing career development programmes for student-athletes interested in medicine.

This review emphasises the need to support and inspire athletes with an interest in pursuing medicine. Elite-level athletes with aspirations to become physicians often believe they cannot achieve both goals.[43] However, athletes are not only able to enter medicine, but this review suggests they excel in medicine. When evaluating medical school candidates, many admissions committees already weigh competencies that athletes may possess such as teamwork, communication and time management. As such, it may be advantageous for educational institutions to continue considering participation in athletics in the admissions process while also encouraging athletes to pursue a career in medicine. More work should be done to inspire student-athletes and show them that the skills they are acquiring through sport are transferable to a career in medicine. Broadly emphasising the importance of qualities that make successful physicians along with objective measures of academic prowess bodes well for the future of medicine.

4.1 | Limitations

This study has some notable limitations. The tendency of the reported studies to include statistically significant findings is likely due to publication bias. A majority of the studies reviewed included a retrospective study design. Additionally, the most common method of ascertaining prior sports participation within the included studies was through self-reported questionnaires or surveys. This may introduce social-desirability bias or recall bias. While some included studies evaluated participation in athletics by level (i.e. varsity athlete versus Olympian) or type of sport played (i.e. individual sport versus team sport), more research may be necessary to understand what type of athletic participation confers skills needed for future success in medicine. Additionally, most of these studies focused on the performance of medical students. The studies evaluated which include residents and/or attending physicians focus primarily on surgical disciplines and include a relatively small sample size.

Future research should also work to define the specific elements that contribute to the potential correlation between athletics and success in medicine. Further establishing these underlying skills would allow admissions committees to select candidates, whether athletes or non-athletes, that possess the skillsets and experiences most predictive of later success in medicine. Additionally, research on this topic should likewise collect and control for demographic information such as race, gender, socioeconomic status and scholarship status. Given the limited availability of data, future investigation is needed to better understand the relationship between former participation in athletics and success in medicine.

4.2 | Conclusions

This study synthesises the current literature on the performance of athletes in medical school, residency and as attending physicians. Despite the vast amount of literature on performance in medicine and proposed interventions to improve medical education, diversity in medicine and medical admissions processes, there is limited literature evaluating the relationship between previous experience in athletics and performance in medicine. Though limited, the current literature suggests former participation in athletics may be a predictor of success in medical school and residency. Specifically, multiple studies indicate that former athletes demonstrated increased surgical skill proficiency and decreased burnout as medical students and residents. The observed relationship may be due to a number of skills many athletes possess—such as teamwork, communication, resilience and time management. Educational institutions and admissions committees should support athletes interested in medicine and consider the demonstration of these skills when evaluating candidates.

AUTHOR CONTRIBUTIONS

All authors gave final approval to the submitted paper and made substantial contributions to the conception, design, completion and editing of the submitted paper. All authors have agreed to be accountable for all aspects of the work. Jacie Lemos (JL), Kathryn Anderson (KA) and Samantha Pickell (SP) were involved in the conception, design, analysis, writing and editing. Christopher Stave (CS) was primarily involved in the design/methods and the editing, although he

was involved at every step of the article. Michael Sgroi (MS) was primarily involved in the conception, design and editing, although he was involved at every step of the article.

ACKNOWLEDGEMENTS

None.

ETHICS STATEMENT

Not applicable.

ORCID

Kathryn G. Anderson https://orcid.org/0000-0002-7046-1940
Jacie Lemos https://orcid.org/0000-0002-7235-2860
Samantha Pickell https://orcid.org/0000-0003-1494-2990
Christopher Stave https://orcid.org/0000-0001-8232-3994
Michael Sgroi https://orcid.org/0000-0003-1832-6108

REFERENCES

1. 2020 Fall Applicant, Matriculant, and Enrollment Data Tables. AAMC. Accessed November 28, 2021. https://www.aamc.org/data-reports
2. Hanson JT, Busche K, Elks ML, et al. The validity of MCAT scores in predicting students' performance and progress in medical school: results from a multisite study. *Acad Med*. 2022;97(9):1374-1384. doi:10.1097/ACM.0000000000004754
3. Peskun C, Detsky A, Shandling M. Effectiveness of medical school admissions criteria in predicting residency ranking four years later. *Med Educ*. 2007;41(1):57-64. doi:10.1111/j.1365-2929.2006.02647.x
4. Jacobparayil A, Ali H, Pomeroy B, Baronia R, Chavez M, Ibrahim Y. Predictors of performance on the United States medical licensing examination step 2 clinical knowledge: a systematic literature review. *Cureus*. 2022;14(2):e22280. doi:10.7759/cureus.22280
5. Schneid SD, Kelly CJ, Brandl K. Relationships between preadmission variables and academic outcomes for postbaccalaureate students in medical school. *Adv Health Sci Educ Theory Pract*. 2022;27(4):1033-1048. doi:10.1007/s10459-022-10129-3
6. Kreiter CD, Axelson RD. A perspective on medical school admission research and practice over the last 25 years. *Teach Learn Med*. 2013;25(sup1):S50-S56. doi:10.1080/10401334.2013.842910
7. Using MCAT Data in 2022 Medical Student Selection. AAMC. Accessed November 28, 2021. https://www.aamc.org/services/mcat-admissions-officers/publications-presentations
8. Docs A. Holistic Review in Medical School Admissions. Students & Residents. Accessed December 22, 2022. https://students-residents.aamc.org/choosing-medical-career/holistic-review-medical-school-admissions
9. Purdy AC, Smith BR, Amersi F, et al. Characteristics associated with outstanding general surgery residency graduate performance, as rated by surgical educators. *JAMA Surg*. 2022;157(10):918-924. doi:10.1001/jamasurg.2022.3340
10. Claessen FMAP, Beks RB, Schol I, Dyer GS. What predicts outstanding orthopedic residents among the program? *Arch Bone Jt Surg*. 2019;7(6):478-483.
11. Strowd LC, Gao H, O'Brien MC, Reynolds P, Grier D, Peters TR. Performing under pressure: varsity athletes excel in medical school. *MedSciEduc*. 2019;29(3):715-720. doi:10.1007/s40670-019-00730-4
12. Babenko O, Mosewich A. In sport and now in medical school: examining students' well-being and motivations for learning. *Int J Med Educ*. 2017;8:336-342. doi:10.5116/ijme.59b7.8023
13. Babenko O, Mosewich A, Sloychuk J. Students' perceptions of learning environment and their leisure-time exercise in medical school: does sport background matter? *Perspect Med Educ*. 2020;9(2):92-97. doi:10.1007/s40037-020-00560-w
14. Dobosz RP, Beaty LA. The relationship between athletic participation and high school students' leadership ability. *Adolescence*. 1999;34(133):215-220.
15. Kniffin KM, Wansink B, Shimizu M. Sports at work: anticipated and persistent correlates of participation in high school athletics. *J Leadersh Organ Stud*. 2015;22(2):217-230. doi:10.1177/1548051814538099
16. What Do 65% of the Most Powerful Women Have In Common? Sports. Fortune. Accessed December 21, 2022. https://fortune.com/2017/09/22/powerful-women-business-sports/
17. Moher D, Liberati A, Tetzlaff J, Altman DG. The PRISMA group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med*. 2009;6(7):e1000097. doi:10.1371/journal.pmed.1000097
18. Medical School Admission Requirements (MSAR): The Most Authoritative Guide to U.S. and Canadian Medical Schools by (AAMC) Association of American Medical Colleges (2011-04-01) Paperback. RuveneCo Inc.; 1697.
19. Wells G, Shea B, O'Connell D, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. Ottawa Hospital Research Institute. Accessed January 28, 2021. http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp
20. Modesti PA, Reboldi G, Cappuccio FP, et al. Panethnic differences in blood pressure in Europe: a systematic review and meta-analysis. *PLoS ONE*. 2016;11(1):e0147601. doi:10.1371/journal.pone.0147601
21. Breitkopf DM, Vaughan LE, Hopkins MR. Correlation of behavioral interviewing performance with obstetrics and gynecology residency applicant characteristics. *J Surg Educ*. 2016;73(6):954-958. doi:10.1016/j.jsurg.2016.05.015
22. Camp CL, Wang D, Turner NS, Grawe BM, Kogan M, Kelly AM. Objective predictors of grit, self-control, and conscientiousness in orthopaedic surgery residency applicants. *J am Acad Orthop Surg*. 2019;27(5):e227-e234. doi:10.5435/JAAOS-D-17-00545
23. Chan M, Bax N, Woodley C, Jennings M, Nicolson R, Chan P. The first OSCE; does students' experience of performing in public affect their results? *BMC Med Educ*. 2015;15(1):59. doi:10.1186/s12909-015-0343-0
24. Chole RA, Ogden MA. Predictors of future success in otolaryngology residency applicants. *Arch Otolaryngol Head Neck Surg*. 2012;138(8):707-712. doi:10.1001/archoto.2012.1374
25. Cychosz CC, Tofte JN, Johnson A, Carender C, Gao Y, Phisitkul P. Factors impacting initial arthroscopy performance and skill progression in novice trainees. *Iowa Orthop J*. 2019;39(1):7-13.
26. Harbison RA, Johnson KE, Miller C, Sardesai MG, Davis GE. Face, content, and construct validation of a low-cost, non-biologic, sinus surgery task trainer and knowledge-based curriculum. *Int Forum Allergy Rhinol*. 2017;7(4):405-413. doi:10.1002/alr.21883
27. Harper JD, Kaiser S, Ebrahimi K, et al. Prior video game exposure does not enhance robotic surgical performance. *J Endourol*. 2007;21(10):1207-1210. doi:10.1089/end.2007.9905
28. Hayden SR, Hayden M, Gamst A. What characteristics of applicants to emergency medicine residency programs predict future success as an emergency medicine resident? *Acad Emerg Med*. 2005;12(3):206-210. doi:10.1197/j.aem.2005.01.002
29. Maxfield CM, Grimm LJ. The value of numerical USMLE step 1 scores in radiology resident selection. *Acad Radiol*. 2020;27(10):1475-1480. doi:10.1016/j.acra.2019.08.007
30. Naylor RA, Reisch JS, Valentine RJ. Factors related to attrition in surgery residency based on application data. *Arch Surg*. 2008;143(7):647-651. doi:10.1001/archsurg.143.7.647
31. Richey BP, Deal MJ, Baker A, et al. Predictors of performance on the arthrobox arthroscopy simulator for medical students. *Arthrosc*

Sports Med Rehab. 2020;2(6):e829-e837. doi:10.1016/j.asmr.2020.07.022
32. Shee K, Ghali F, Hyams ES. MP11-09 prior experience in athletics is significantly associated with increased robotic surgical skill in robot-naive medical students. *J Urol*. 2016;195(4S):e114-e115. doi:10.1016/j.juro.2016.02.2380
33. Zeng W, Woodhouse J, Brunt LM. Do preclinical background and clerkship experiences impact skills performance in an accelerated internship preparation course for senior medical students? *Surgery*. 2010;148(4):768-776. doi:10.1016/j.surg.2010.07.022
34. Lodewyk K, Linkiewich D, Lee A, Babenko O. From jerseys to scrubs: is sport background associated with medical students' tolerance of ambiguity and uncertainty? *Health Prof Educ*. 2020;6(4):501-505. doi:10.1016/j.hpe.2020.07.005
35. Miller NM, McGowen RK. The painful truth: physicians are not invincible. *South Med J*. 2000;93(10):966-973. doi:10.1097/00007611-200093100-00004
36. Spickard A Jr, Gabbe SG, Christensen JF. Mid-career burnout in generalist and specialist physicians. *Jama*. 2002;288(12):1447-1450. doi:10.1001/jama.288.12.1447
37. Hyman SA, Michaels DR, Berry JM, Schildcrout JS, Mercaldo ND, Weinger MB. Risk of burnout in perioperative clinicians: a survey study and literature review. *Anesthesiology*. 2011;114(1):194-204. doi:10.1097/ALN.0b013e318201ce9a
38. Gazelle G, Liebschutz JM, Riess H. Physician burnout: coaching a way out. *J Gen Intern Med*. 2015;30(4):508-513. doi:10.1007/s11606-014-3144-y
39. Grabowski CJ. Impact of holistic review on student interview pool diversity. *Adv Health Sci Educ Theory Pract*. 2018;23(3):487-498. doi:10.1007/s10459-017-9807-9
40. Harrison LE. Using holistic review to form a diverse interview pool for selection to medical school. *Proc (Bayl Univ Med Cent)*. 2019;32(2):218-221. doi:10.1080/08998280.2019.1576575
41. 3000 by 2000: A history of the visionary campaign to diversify med schools, and what got in its way. WHYY. Accessed December 21, 2022. https://whyy.org/segments/3000-by-2000/
42. Black Male Student-Athletes and Racial Inequities in NCAA Division I College Sports, 2018 Update. Accessed December 21, 2022. https://search.issuelab.org/resource/black-male-student-athletes-and-racial-inequities-in-ncaa-division-i-college-sports-2018-update.html
43. Do student-athletes make good doctors? AAMC. Accessed February 10, 2021. https://www.aamc.org/news-insights/do-student-athletes-make-good-doctors
44. The Price of Poverty in Big Time College Sport. Accessed December 21, 2022. https://www.ncpanow.org/research/study-the-price-of-poverty-in-big-time-college-sport

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Anderson KG, Lemos J, Pickell S, Stave C, Sgroi M. Athletes in medicine: A systematic review of performance of athletes in medicine. *Med Educ*. 2023;57(9):807-819. doi:10.1111/medu.15033