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Up Front and Open? Shrouded in Secrecy? Or Somewhere in Between? A Meta-Research Systematic Review of Open Science Practices in Sport Medicine Research

OBJECTIVE: To investigate open science practices in research published in the top 5 sports medicine journals from May 1, 2022, and October 1, 2022.

DESIGN: A meta-research systematic review.

LITERATURE SEARCH: Open science practices were searched in MEDLINE.

STUDY SELECTION CRITERIA: We included original scientific research published in one of the identified top 5 sports medicine journals in 2022 as ranked by Clarivate: (1) *British Journal of Sports Medicine*, (2) *Journal of Sport and Health Science*, (3) *American Journal of Sports Medicine*, (4) *Medicine and Science in Sports and Exercise*, and (5) *Sports Medicine-Open*. Studies were excluded if they were systematic reviews, qualitative research, gray literature, or animal or cadaver models.

DATA SYNTHESIS: Open science practices were extracted in accordance with the Transparency and Openness Promotion guidelines and patient and public involvement.

RESULTS: Two hundred forty-three studies were included. The median number of open science practices in each study was 2, out of a maximum of 12 (range: 0-8; interquartile range: 2). Two hundred thirty-four studies (96%, 95% confidence interval [CI]: 94%-99%) provided an author conflict-of-interest statement and 163 (67%, 95% CI: 62%-73%) reported funding. Twenty-one studies (9%, 95% CI: 5%-12%) provided open-access data. Fifty-four studies (22%, 95% CI: 17%-27%) included a data availability statement and 3 (1%, 95% CI: 0%-3%) made code available. Seventy-six studies (32%, 95% CI: 25%-37%) had transparent materials and 30 (12%, 95% CI: 8%-16%) used a reporting guideline. Twenty-eight studies (12%, 95% CI: 8%-16%) were preregistered. Six studies (3%, 95% CI: 1%-4%) published a protocol. Four studies (2%, 95% CI: 0%-3%) reported an analysis plan a priori. Seven studies (3%, 95% CI: 1%-5%) reported patient and public involvement.

CONCLUSION: Open science practices in the sports medicine field are extremely limited. The least followed practices were sharing code, data, and analysis plans. *J Orthop Sports Phys Ther 2023;53(12):735-747. Epub 20 October 2023. doi:10.2519/jospt.2023.12016*

KEY WORDS: *open access, open code, reporting guideline, study protocol*

Sports medicine and science research has improved knowledge and practice in preventing and managing medical and injury problems, and improving athlete performance.[35,56] Nevertheless, the fields have been plagued by poor reporting of study quality and conduct, which holds the fields back.[4,29,56] Although not an exhaustive list, methodological flaws and misconduct such as "p-hacking," hypothesizing after the results are known (HARKing),[14] and coding and statistical errors[27] are common and threaten the validity of study results.[3,14]

Opaque design, conduct, and reporting of studies (including unavailability of protocols, analysis plans, code, and data) allows problems to fester.[14,22,49] It is often difficult for practitioners and researchers to identify valid findings from well-designed studies, and poor research practice limits the accuracy of aggregated analyses of systematic reviews and meta-analyses.[53,54] Small sample sizes in datasets from individual teams or organizations do not help,[7,28,39,40,57] with imprecise estimates and exaggerated effects further confusing readers.[1,5,13] While data sharing initiatives can overcome sample size barriers, a team's proprietary data are often strongly protected[21] and not shared.

Open science is a movement to make all materials and results accessible to all

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levels of society[65] and encourages the free sharing of protocols and analysis plans, study registration, results, data, and code.[31] Open science is more than open-access publishing; open science practices can improve athlete health and allows fellow scientists to understand, evaluate, replicate, and confirm previous research from transparent methods, open data, and code.[12,37,64] Open science practices have been comparatively well adopted in the physical and biological sciences.[56] However, due to patient privacy and confidentiality, these fields do not have the same ethical considerations as the medical sciences.[6,31,56] In sports medicine and science, adopting open science is further complicated because of competition between clubs and the potential of athlete reidentification.[12] Funders and charity organizations increasingly require plans for open science practices to be embedded in grant applications for funded sports medicine research.[6,31,56]

It is unclear to what extent open science practices are adopted in sports medicine and science research. Previous reports have highlighted the need to increase open science practices in sport,[24,40,61] judged journals' Transparency and Openness Promotion (TOP) factor scores,[61] evaluated data sharing statements and preregistration in randomized controlled trials (RCTs),[24] and discussed evidence of poor data sharing practices.[40] Understanding where sports medicine and science is at with open science will help academics, practitioners, journal editors, reviewers, and funding bodies improve open science practices, potentially accelerating collaboration, methodological transparency, and athlete health outcomes.[8,11,12]

The purpose of this study was to investigate of open science practice in research published in the top 5 sports medicine journals from May 1, 2022, to October 1, 2022.

METHODS

The design of this meta-research systematic review was informed by previous work by Hardwicke et al.[26] This study was reported using Joanna Briggs Institute guidelines for reporting methodology research[44] and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocol (PRISMA-P).[42] Evaluation of open science practice was informed by 2 sources: evaluating implementation of the TOP guidelines[37] and the review by Tennant et al,[60] which included evaluation of patient public involvement. Our review was prospectively registered on the Open Science Framework (https://osf.io/4amek/). The final draft manuscript was uploaded and made available on the medRxiv preprint server prior to peer review (https://www.medrxiv.org/content/10.1101/2023.03.30.23287959v1).

Relevant Party Involvement (ie, Patient and Public Involvement)

The research question was developed by an author working committee of nonacademic partners and individuals who had an interest in or were involved in amateur, collegiate, and professional sport. The working committee included physiotherapists, physicians, sports performance coaches, athletic trainers, and statistical and methodological researchers. The working committee met virtually to discuss strategy and study progress, preliminary results and interpretation of findings, and provide input into the plan for dissemination of findings.

Equity, Diversity, and Inclusion

After consideration of the necessity to involve relevant parties and collaborators with required expertise, the author team consists of a diverse range of individuals, including students, clinicians, and early, middle, and late career researchers with balance of people who identify as men and women, different age groups, and nationalities.

Study Eligibility Criteria

Article inclusion and exclusion criteria are reported in **TABLE 1**.

Search Strategy and Journal Selection

Sports medicine journals were chosen based on Clarivate journal citation rankings. While these rankings have limitations,[23,46] this method was chosen to remove author subjectivity and avoided cherry picking journals. After excluding journals that are focused on systematic reviews (*Sports Medicine*; *Exercise Immunology Review*) and qualitative research (*Qualitative Research in Sport, Exercise and Health*), the top 5 journals were (1) *British Journal of Sports Medicine* (BJSM), (2) *Journal of Sport and Health Science* (JSHS), (3) *American Journal of Sports Medicine* (AJSM), (4) *Medicine and Science in Sports and Exercise* (MSSE), and (5) *Sports Medicine-Open* (SMO). These 5 journals were searched through MEDLINE on October 10, 2022, for all

TABLE 1 Article Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Studies published in one of the identified top 5 sports medicine journals ranked by Clarivate journal citation rankings: (1) *British Journal of Sports Medicine*, (2) *Journal of Sport and Health Science*, (3) *American Journal of Sports Medicine*, (4) *Medicine and Science in Sports and Exercise*, (5) *Sports Medicine-Open*)	Systematic reviews, scoping reviews, meta-analysis
Studies published in special edition journal issues	Qualitative research
Original scientific research published as a full peer reviewed paper	Case reports, editorials, letters to the editor
Randomized control trials, observational studies	Gray literature
Published in English	Studies using animal and cadaver models

articles published over a 6-month time period, between May 1, 2022, and October 1, 2022 (**APPENDIX A**).

Study Selection

All reviewers participated in an online training session (led by G.B.) that provided information for article screening and the data extraction process. A calibration exercise, consisting of reviewer education, a full group grading of 1 paper, and then independent screening and grading of 5 papers, followed by discussion was then performed prior to screening. All reviewers were required to achieve greater than 90% agreement between their screening and the lead authors decisions on the sample of articles prior to official screening. Titles and abstracts were screened independently for eligibility in equal numbers of randomized articles by paired screening groups (P.W. and F.I., T.H. and C.H., K.D. and K.H., E.B. and K.H., A.R. and C.G., G.F. and J.W., T.S. and R.Z.). The full-text of eligible studies were then recovered and screened independently by the same screening pairs.[4,5] Title and abstract and full-text study disputes were resolved by consensus within each screening pair. If consensus could not be resolved, the lead author (G.B.) had final resolution on study inclusion or exclusion. Selected full-text articles were retrieved through university online library portals. If a study could not be retrieved, the authors were contacted to request full text, and if required, interlibrary loan with the assistance of a librarian was attempted. If a full-text article could not be retrieved, the study was excluded from the review.[9,10,45] All screening was performed in Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia).

Data Extraction

Data were extracted by the same screening pairs (P.W. and F.I., T.H. and C.H., K.D. and K.H., E.B. and K.H., A.R. and C.G., G.F. and J.W., T.S. and R.Z.), entered into a customized electronic database, using the recommended practices of The National Institute for Health and Care Excellence evidence tables.[18,43] Conflicts were resolved first by consensus, followed by the lead author (G.B.). A random sample of 3 articles from each data extraction team were screened and graded by the study leads (G.B., G.C.) for quality control. Data extraction included author details (eg, first author surname, title, study design, journal, month of publication, and sport). Open science methods were extracted in accordance with the TOP guidelines,[37] with an additional criterion covering patient and public involvement (**TABLE 2**).[60] Any articles that were electronic publications ahead of print were extracted and included but were not scored on open science criteria that would not be required prior to full publication such as disclosing author conflicts or reporting funding.

The 5 journals selected for review were also evaluated on whether the journal required publications to adhere to open science criteria. Open science data were extracted at the journal level by the lead authors (G.B., G.C.). The open science data were extracted as a "yes" or "no" for meeting the criteria.

Collating, Summarizing, and Reporting the Results

Overall screening agreement and quality control agreement were calculated by Cohen's weighted kappa. The proportion of articles meeting each criterion for open science was calculated along with a 95% confidence interval. To evaluate potential systematic differences in open science,

TABLE 2 Open Science Practices Evaluated in the Review (Adapted From the TOP Guidelines[37])

Open Science Practice	Criterion
1. Conflict-of-Interest Statement	Manuscript provides details on any author conflicts of interest.
2. Funding Statement	Manuscripts describe funding, and the role of any funders.
3. Data Citation	Manuscript provides details on the provenance of data, with a clear identifier (eg, digital object identifiers, website, or link to digital repository).
4. Data Transparency	Manuscript states where any data are available (eg, in a data sharing statement), such as a data warehouse or repository, and where to access them through an embedded link. May be within manuscript, or as a separate section (ie, data availability statement).
5. Analysis Code Transparency	Manuscript includes details on code availability (ie, in supplementary materials, or has an available link to a repository within the manuscript).
6. Materials Transparency	Manuscript state where any materials (such as patient reported outcomes or survey questions) are available, eg, included as an appendix or a link to a repository.
7. Design & Analysis Reporting Guideline	Manuscript cites and claims use of an appropriate reporting guideline.
8. Study Registration	Manuscripts state study registration number with an open-access database (eg, Prospero, clinicatrials.gov).
9. Study Protocol	Manuscripts states a study protocol was available in an open-access repository (eg, Open Science Framework) or published in an open-access journal.
10. Statistical Analysis Plan	Manuscripts states a statistical analysis plan was available in an open-access repository (eg, Open Science Framework) or published in an open-access journal.
11. Patient & Public Involvement	Manuscript describes any patient and public involvement, also known as 'citizen science'.
12. Replication	Replication studies that explicitly described their aim was replication of validate previous research.

data were also stratified according to journal, study design, and sport. Open science practices were analyzed by sport as different sports have different cultures, data collection methods, and different methodological experts heavily involved in these sports. The scientific training of different content and methodological expertise may explain differences in how they design, register, and report their findings. Due to small sample size and proportions at or around zero, Clopper-Pearson confidence intervals were calculated for proportions.[51] Data were summarized and presented as median, range, and interquartile range (IQR) of articles meeting open science practices. A narrative synthesis was performed. All analyses were performed in R 4.02 (R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/). The *dplyr* package was used for cleaning and calculations.

Code Sharing

Analytical code used to summarize the findings in this paper are available on the Open Science Framework (https://osf.io/4amek/).

RESULTS

After removing duplicates, 360 titles and abstracts were identified over the 6-month sample period for the 5 sports medicine journals. Through title and abstract screening, we excluded letters to the editor and other nonprimary scientific research. The screening process identified 243 studies that met our inclusion criteria (**FIGURE 1**). Overall, the Kappa agreement between reviewers for data extraction was 0.86 and random sample quality control agreement was 0.98, which are both deemed as excellent agreement.

Study Characteristics

Of the 243 included studies, 20 (8%, 95% CI: 5%-12%) were included from the BJSM, 5 (2%, 95% CI: 0%-7%) from JSHS, 112 (46%, 95% CI: 40%-53%) from the AJSM, 85 (35%, 95% CI: 29%-41%) from MSSE, and 21 (9%, 95% CI: 5%-13%) from SMO.

A total of 94 studies (39%, 95% CI: 33%-45%) were prospective cohort studies, 58 (24%, 95% CI: 19%-30%) retrospective cohort, 32 (13%, 95% CI: 9%-18%) cross-sectional, 29 (12%, 95% CI: 8%-17%) were RCTs, 14 (6%, 95% CI: 3%-9%) case-control, 14 (6%, 95% CI: 3%-9%) case series, 1 (<1%, 95% CI: 0%-2%) quasi-experimental, and 1 (<1%, 95% CI: 0%-2%) economic and decision analysis.

A total of 81 studies (33%, 95% CI: 27%-40%) investigated general population exercise, 57 (23%, 95% CI: 18%-29%) multiple sports, 51 (21%, 95% CI: 16%-27%) general orthopaedics, 15 (6%, 95% CI: 3%-10%) running, 10 (4%, 95% CI: 2%, 7%) baseball, 4 (2%, 95% CI: 1%-4%) cycling, 4 (2%, 95% CI: 1%-4%) military, 3 (1%, 95% CI: 0%-4%) soccer, 3 (1%, 95% CI: 0%-4%) swimming and diving, 2 (1%, 95% CI: 0%-3%) American football, and 1 (<1%, 95% CI: 0%-2%) for individual sports of basketball, e-sports, handball, lacrosse, motor sports, netball, occupational

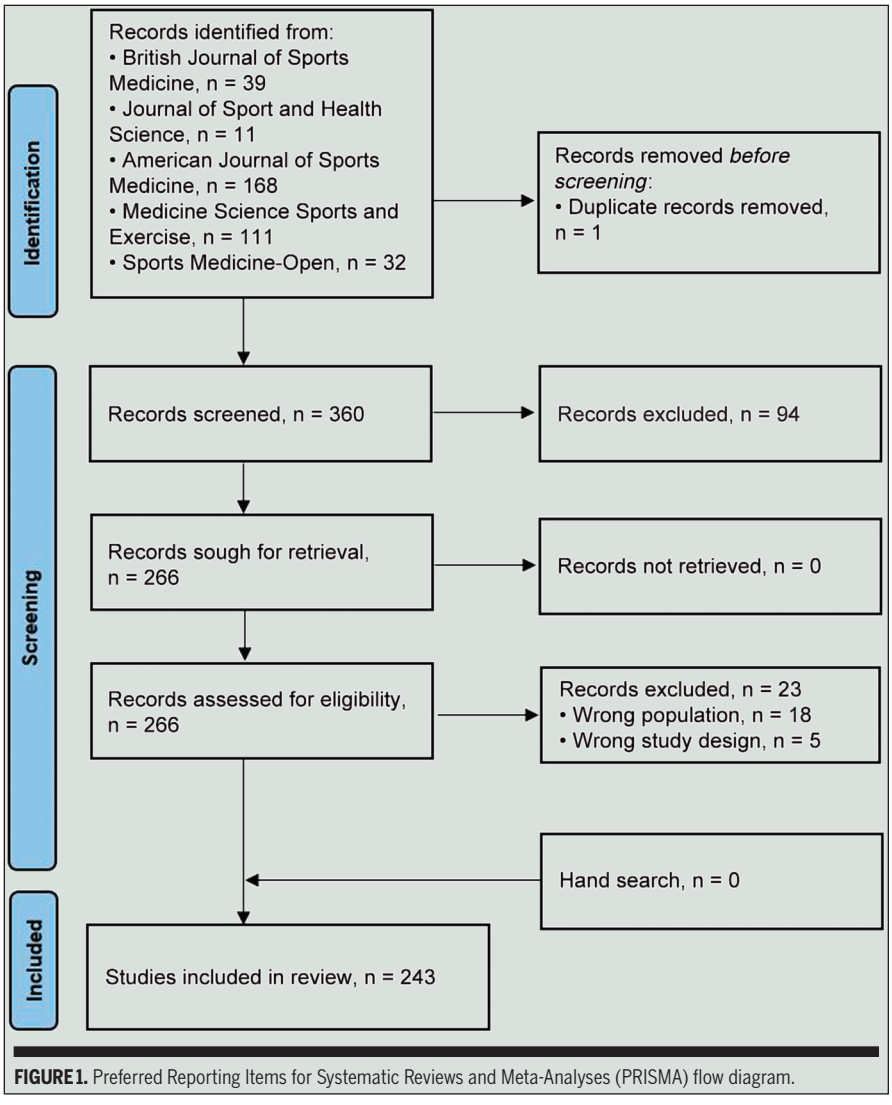

FIGURE 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

TABLE 3 Journal Open Science Practices

Open Science Criterion	BJSM	JSHS	AJSM	MSSE	SMO
Conflict-of-Interest Statement	Yes	Yes	Yes	Yes	Yes
Funding Transparency	Yes	Yes	Yes	Yes	Yes
Data Citation	No	No	No	No	No
Data Transparency	Yes	Yes	No	No	Yes
Analysis Code Transparency	No	No	No	No	No
Materials and Method Transparency	No	No	No	No	No
Design and Analysis Reporting Guideline	Yes	Yes	Yes	No	No
Study Preregistration	No[a]	No	No[a]	No	No
Study Protocol Preregistration	No	No	No	No	No
Analysis Plan Preregistration	No	No	No	No	No
Patient and Public Involvement	Yes	No	No	No	No

Abbreviations: AJSM, American Journal of Sports Medicine; BJSM, British Journal of Sports Medicine; JSHS, Journal of Sport and Health Science; MSSE, Medicine and Science in Sports and Exercise; SMO, Sports Medicine-Open.
[a]*Partially met criteria for a specific subset of study designs.*

population, pregnant athletes, rowers, and skiing.

Evaluation of Open Science Practices

One journal (BJSM) encouraged the most open science practices (**TABLE 3**), with conflict-of-interest statement, funding transparency, data transparency, reporting guidelines, and patient public involvement. The median number of open science practices met per journal was 3.5 (range: 2-5; IQR: 1).

No studies met all open science practices. The highest rated study (<0.1%, 95% CI: 0%-2%) met 8 out of 12 open science criteria. The median number of open science practices met per study was 2 (range: 0-8; IQR: 2). Please refer to supplementary data (https://osf.io/4amek/) for individual study evaluations.

A total of 234 (96%, 95% CI: 93%-98%) reported author conflicts, and 163 (67%, 95% CI: 61%-73%) provided details on funding. A total of 21 (9%, 95% CI: 5%-13%) provided open-access data through an embedded link or made data available in the supplementary material. Fifty-four (22%, 95% CI: 17%-28%) included a data availability statement or signposted where data were available. Of these 54 studies, 39 (72 %, 95% CI: 58%-84%) reported that data were available upon reasonable request, and 15 (28%, 95% CI: 16%-42%) reported a publicly available site to request data. Three studies of the 54 that reported that data were available upon reasonable request (6%, 95% CI: 1%-15%) provided a link, made available the supplementary material, or highlighted where open-access code was available.

Seventy-six studies (32%, 95% CI: 22%-34%) had fully transparent and available materials and methods. Twenty-eight studies (12%, 95% CI: 8%-16%) reported following a reporting guideline. Of these, 14 (50%, 95% CI: 31%-69%) of the RCT studies reported the Consolidated Standards of Reporting Trials (CONSORT)

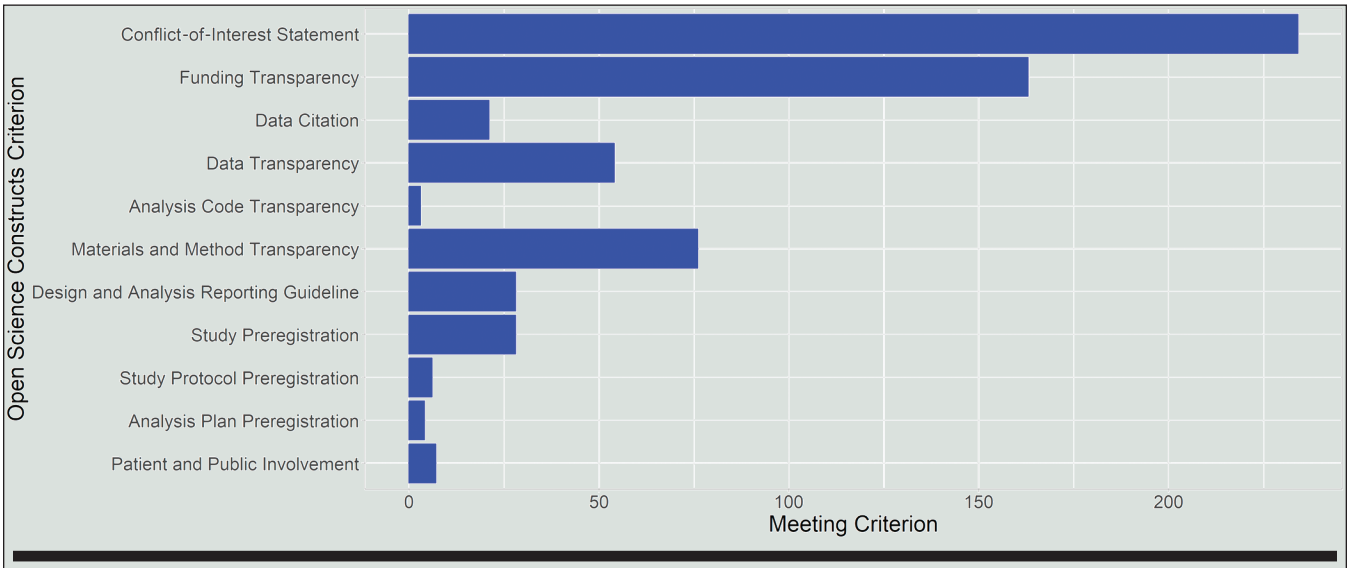

FIGURE 2. Breakdown of open science practice.

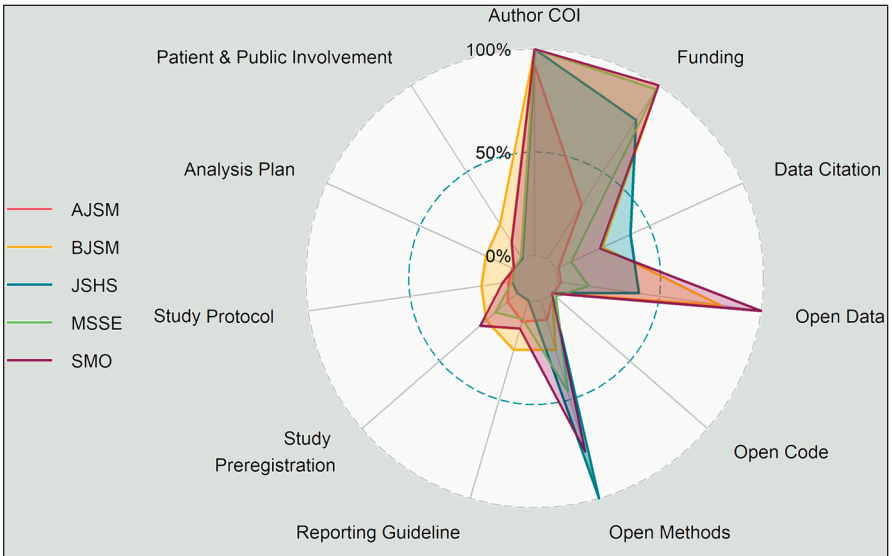

FIGURE 3. Open sciences practices by journal. Replication is not reported as no studies were replication. Abbreviations: AJSM, American Journal of Sports Medicine; BJSM, British Journal of Sports Medicine; COI, conflict of interest; JSHS, Journal of Sport and Health Science; MSSE, Medicine and Science in Sports and Exercise; SMO, Sports Medicine-Open.

guidelines,[2] 11 (39%, 95% CI: 22%-59%) of the observational studies reported the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines,[62] 4 (14%, 95% CI: 4%-33%) prediction studies reported the Transparent reporting of a multivariable prediction model for individual prognosis or diagnosis (TRIPOD) guidelines,[17] and 1 (4%, 95% CI: 0%-18%) internet survey study reported the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) guidelines.[20] Twenty eight studies (12%, 95% CI: 8%-16%) reported preregistration and 6 (3%, 95% CI: 1%-5%) published a protocol in an open-access journal or placed it in an open science repository. Four (2%, 95% CI: 0%-4%) reported the availability of an analysis plan. No studies (0%, 95% CI: 0%-2%) were replication studies. Seven studies (3%, 95% CI: 1%-6%) reported patient and public involvement or citizen science. (**FIGURE 2**).

Open Science Practices by Journal

The median number of open science practices met per article for BJSM was 3 (range: 2-8; IQR: 3), the median for JSHS was 3 (range: 3-5; IQR: 1), the median for AJSM was 1 (range: 1-7; IQR: 1), the median for MSSE was 2 (range: 0-6; IQR: 1), and the median for SMO was 4 (range: 3-7; IQR: 1).

Greater than 50% of studies published in each journal reported author conflicts and funding. Less than 40% of studies reported for data citation in each journal, and only 2 journals (AJSM and MSSE) had any articles report open-access code. The use of reporting guidelines was reported in 25% or less of studies published in each journal. Only studies in 2 journals (AJSM and BJSM) reported the availability of statistical analyses plans. Studies in the BJSM were twice as likely to report patient and public involvement (**FIGURE 3**; **APPENDIX B**)

Open Science Practices by Study Design

The median number of open science practices met per study for RCTs was 4 (range: 1-8; IQR: 2), the median for prospective cohorts was 2 (range: 0-6; IQR: 2), the median for retrospective cohorts was 1 (range: 1-4; IQR: 1), the median for case-controls was 2 (range: 1-7; IQR: 2), the median for cross-sectional studies was 2 (range: 1-5; IQR: 3), the median for case series was 1 (range: 1-6; IQR: 0). Economic and decision analyses and quasi-experimental studies both only included 1 study.

All study designs had similar percentage in terms of meeting the open science criteria for author conflicts, funding, data transparency, and analysis and code transparency. RCTs had 4 times greater

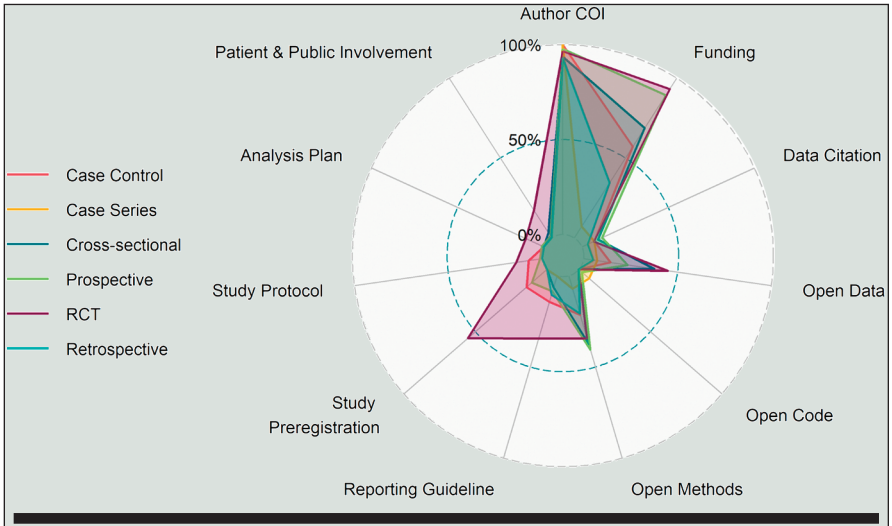

FIGURE 4. Open sciences practices by study design. Replication is not reported as no studies were replication. Abbreviations: COI, conflict of interest; RCT, randomized controlled trial.

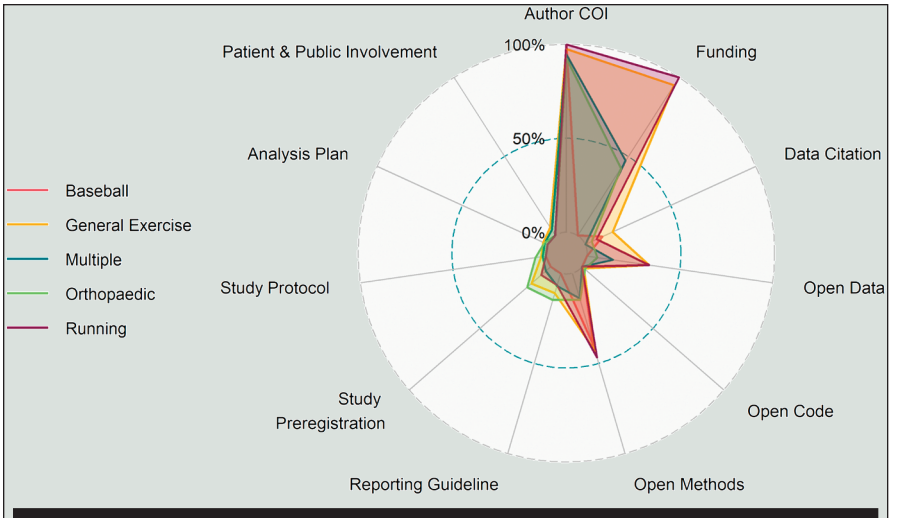

FIGURE 5. Open sciences practices by sport. Replication is not reported as no studies were replication. Abbreviation: COI, conflict of interest.

percentage of studies that used reporting guidelines and 5 times greater percentage for registering a study. RCTs had 3 times greater percentage for reporting availability of a statistical analysis plan, and 5 times greater percentage for reporting patient and public involvement (**FIGURE 4**; **APPENDIX B**)

Open Science Practices by Sport

The median number of open science practices met per study for general population exercise was 2 (range: 0-8; IQR: 2), the median for multiple sports was 1 (range: 1-5; IQR: 1), the median for general orthopaedic patients was 2 (range: 1-7; IQR: 1), the median for running was 3 (range: 1-5; IQR: 2), and the median for baseball was 1 (range: 1-3; IQR: 1).

All sport, exercise, and orthopaedic population studies demonstrated a similar percentage for meeting open science criterion for author conflicts, funding, data transparency, analysis and code transparency, study registration, analysis plan, and patient and public involvement. Studies that involved patients with orthopaedic conditions had 2 times greater percentage of using a reporting guideline compared to studies that studied investigated sport and exercise populations (**FIGURE 5**; **APPENDIX B**).

DISCUSSION

None of the journals or studies from the top 5 sports medicine journals in 2022 met all open science practices. One study met 8 out of 11 open science practices, whereas the median number of open science practices met was only 2. The overall adherence to open science principles in the sport medicine and research field is extremely low. Open science practices that were least likely to be encouraged by journals or practiced in individual studies were sharing of analysis code, sharing data, and the availability of an analysis plan. When stratifying by study design, RCTs reported adopting the most open science practices criteria, and observational studies the least.

The low number of open science practices met is comparable to the social sciences,[26] biology,[30,63] and psychology.[47] The social, biological, and psychological sciences had similarly low adherence to sharing of analysis code, sharing data, and availability of analysis plans.[25,30,47,63] Economics has very low sharing of code and data.[38]

The limited adoption of open science practices makes it challenging to test reproducibility and generalizability of the published research results. An open science initiative replicated 100 psychological studies that reported "statistically significant" results, with only 37% reporting positive results after replication.[48] The improbably high prevalence of statistically significant results is detrimental for users of research.[40] False positives (a "statistically significant" result, when in reality no effect exists) might inadvertently justify a risk factor or interventions that clinicians and organizations invest time and resources to implementing, with no effect or possibly a harmful effect. Without improved and consistent open science uptake and research integrity, sports medicine research will continue languish with poor generalizability of the data and low public trust in research findings.

Sports medicine and science does poorly in sharing open-access analysis code, data, and availability of analytical plans. Freely accessible statistical code and data sharing offers opportunities to other researchers to replicate statistical methods and results,[15,19] it can also facilitate the reporting of errors,[11,12] aggregate findings,[32,55] and combine data from different sources to answer research questions that cannot be answered using single datasets.[11,12] Unavailability of code and data hinders the sports medicine community's ability to confirm results and combine data, to improve cumulative science.[32] While a number of studies reported their data were available upon request, this statement is woefully inadequate, and has not resulted in increased access to data within the greater scientific literature.[33] Thus, the overall prevalence of open data is likely lower than the reported results.

RCTs had modestly better adoption of open science practices compared to other study designs. RCTs are required to register protocols before study recruitment prior at registries such as clinicaltrials.gov. Many journals require RCTs to submit CONSORT[2] checklists at the time of manuscript submission. The stricter study registration and methodological reporting of RCTs is due to the inherent risk, and thus patient

protection required. Other methodological designs used in sport medicine, most notably observational studies, should require the same registration and methodological rigor, as these studies also inform evidence-based practice.[34]

We encourage the sports medicine community and journal editorial boards to make open science practices a priority before publication. Mandating study registration, availability of protocols, analytical plans, data, open-access code, and requiring reporting author conflicts of interest, funding, and guideline checklists at submission are low-hanging fruit, which can be easily implemented across all journals. The practices should also be viewed as performing quality science.[16,41] Reporting patient public involvement, also known as citizen science, is an easy accessible open science practice that can and should be mandated across all journals. While there may be special concerns about sharing sports medicine data,[11,12] these barriers are not insurmountable, as already shown through other biomedical scientific fields.[6,31,56] Potential solutions include creating synthetic (ie, simulated) data that mirrors the characteristics of the actual data,[52] creating a gatekeeper warehouse for data access,[50] and using federated access (ie, data are housed and analyzed only within the data owner's servers).[58]

Mandating open science practices may increase academic and research work. Open science takes commitment and support from the scientific, university, journals, and grant funding organizations. There is little training, funding, or support for sports medicine researchers in open science skills.[36,41] Universities need to support, value and reward researchers who practice open science. There is no current consensus on the barriers and facilitators or legal ramifications of open-access data within sport, and there is a need and opportunity to engage all relevant parties in this discussion.

Limitations

Only studies published across the top 5 ranked journals within sports medicine and science in the Clarivate journal citation rankings were included. This practice has been used in previous open science meta-research.[26] This methodological strategy was employed to reduce bias in journal selection and increase scientific rigor in selection and analyzing of open science practices. Our study was a 6-month sample of selected sports medicine and science journals. It is possible that open science practice in other sports medicine journals may be even more limited, due to the smaller scientific barriers attributed to lower ranking journals.[59] Scoping reviews are broad in nature, which decreases the precision of specific scientific questions.

CONCLUSIONS

Less than 20% of recommended open science practices were currently met by studies published in the top 5 sports medicine journals. Replication, sharing code, data, and availability of analysis plans were the least followed open science practices. Randomized controlled trials had better adherence to open science practices compared to observational studies. ◉

KEY POINTS

FINDINGS: No study published in the top 5 sports medicine journals in 2022 met all open science practices. The open science practices of providing open-access code, data sharing, and the availability of an analysis plan were almost nonexistent in sports medicine and science journals.

IMPLICATIONS: Failing to implement open science practices in sport compromises trust in methods and results, and negatively impacts people who are trying to translate evidence to practice.

CAUTION: This study only included the top 5 sports medicine journals in 2022, as ranked by Clarivate. Other sports medicine journals may demonstrate different open science practices.

STUDY DETAILS

AUTHOR CONTRIBUTIONS: G.B. and G.C. conceived the study idea. G.B. and G.C. designed the study. G.B. and G.C. wrote the initial draft. G.B., P.W., F.I., S.F., T.H., C.H., B.W., K.D., K.H., E.B., K.H., A.R., C.G., G.F., J.W., K.N., T.S., R.Z., P.D., R.R., and G.C. critically revised the manuscript. G.B., P.W., F.I., S.F., T.H., C.H., B.W., K.D., K.H., E.B., K.H., A.R., C.G., G.F., J.W., K.N., T.S., R.Z., P.D., R.R., and G.C. approved the manuscript.

DATA SHARING: The reconciled extracted data that form the results in this study are available in the Open Science Framework (https://osf.io/4amek/).

PATIENT AND PUBLIC INVOLVEMENT: The research question was developed following consultation with several professional groups, including nonacademic partners and individuals who had an interest in or were affected by amateur, collegiate, and professional sport. These groups included physiotherapists, physicians, sports performance coaches, athletic trainers, and statistical and methodological researchers. These groups also met virtually to discuss strategy and study progress, preliminary results and interpretation of findings, and provide input into the plan for dissemination of findings.

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APPENDIX A

SEARCH STRATEGY

British Journal of Sports Medicine, 10/10/2022---39 results:
((((("British Journal of Sports Medicine"[Journal]) AND (("2022/05/01"[Date - Entry]: "2022/10/06"[Date - Entry]))) NOT (Systematic Review)) NOT (Editorial)) NOT (Letter to the Editor) NOT (Narrative) NOT (Meta-Analysis)

Journal of Sport and Health Science, 10/10/2022---11 results:
((((("Journal of Sport and Health Science"[Journal]) AND (("2022/05/01"[Date - Entry]: "2022/10/06"[Date - Entry]))) NOT (Systematic Review)) NOT (Editorial)) NOT (Letter to the Editor) NOT (Narrative) NOT (Meta-Analysis)

The American Journal of Sports Medicine, 10/10/2022---168 results:
((((("The American journal of sports medicine"[Journal]) AND (("2022/05/01"[Date - Entry]: "2022/10/06"[Date - Entry]))) NOT (Systematic Review)) NOT (Editorial)) NOT (Letter to the Editor) NOT (Narrative) NOT (Meta-Analysis)

Medicine and Science in Sports and Exercise, 10/10/2022---111 results:
((((("Medicine and science in sports and exercise"[Journal]) AND (("2022/05/01"[Date - Entry]: "2022/10/06"[Date - Entry]))) NOT (Systematic Review)) NOT (Editorial)) NOT (Letter to the Editor) NOT (Narrative) NOT (Meta-Analysis)

Sports Medicine-Open, 10/10/2022---32 results:
((((("Sports Medicine-Open"[Journal]) AND (("2022/05/01"[Date - Entry]: "2022/10/06"[Date - Entry]))) NOT (Systematic Review)) NOT (Editorial)) NOT (Letter to the Editor) NOT (Narrative) NOT (Meta-Analysis)

APPENDIX B

OPEN SCIENCE CRITERION STRATIFIED BY JOURNAL, STUDY DESIGN, AND SPORT AND EXERCISE

	Conflict of Interest	Funding	Data Citation	Data Transparency	Analysis & Code Transparency	Materials & Methods Transparency	Reporting Guideline	Study Registration	Study Protocol	Analysis Plan	Patient & Public Involvement
Stratified by Journal											
BJSM (n = 20)	20 (100)	20 (100)	5 (25, 9-49)	16 (80, 56-94)	0 (0, 0-10)	5 (25, 9-49)	5 (25, 9-49)	4 (20, 6-44)	3 (15, 3-38)	3 (15, 3-38)	4 (20, 6-44)
JSHS (n = 5)	5 (100)	4 (80, 28-99)	2 (40, 0-83)	2 (40, 0-83)	0 (0, 0-36)	5 (100)	0 (0, 0-36)	0 (0, 0-36)	0 (0, 0-36)	0 (0, 0-36)	0 (0, 0-36)
AJSM (n = 112)	103 (92, 85-96)	35 (31, 23-41)	2 (2, 0-6)	2 (2, 0-6)	1 (1, 0-5)	11 (10, 5-17)	12 (11, 6-18)	7 (6, 3-12)	2 (2, 0-6)	1 (1, 0-5)	0 (1, 0-3)
MSSE (n = 85)	85 (100)	83 (98, 92-100)	7 (8, 3-16)	13 (15, 8-25)	2 (2, 0-8)	39 (46, 35-57)	8 (9, 4-18)	12 (14, 8-23)	0 (0, 0-3)	0 (0, 0-3)	1 (1, 0-6)
Sport Med-Open (n = 21)	21 (100)	21 (100)	5 (24, 8-47)	21 (100)	0 (0, 0-10)	16 (76, 53-92)	3 (14, 3-36)	5 (24, 8-47)	1 (5 , 0-24)	0 (0, 0-10)	2 (9, 1-30)
Stratified by Study Design											
RCT (n = 29)	28 (97, 92-100)	27 (93, 77-99)	2 (7, 1-23)	13 (45, 26-64)	0 (0, 0-8)	10 (34, 18-54)	11 (38, 21-58)	16 (55, 36-74)	4 (14 , 4-32)	3 (10, 2-27)	5 (17, 6-36)
Prospective Cohort (n = 94)	92 (98, 93-100)	84 (89, 81-95)	11 (12, 6-20)	22 (23, 15-33)	2 (2, 0-7)	38 (40, 30-51)	8 (9, 4-16)	10 (11, 5-19)	1 (1, 0-6)	1 (1, 0-6)	1 (1, 0-6)
Retrospective Cohort (n = 58)	54 (93, 83-98)	20 (34, 22-48)	2 (3, 0-12)	3 (5, 1-14)	0 (0, 0-4)	12 (21, 11-33)	5(9, 3-19)	0 (0, 0-4)	0 (0, 0-4)	0 (0, 0-4)	0 (0, 0-4)
Cross-Sectional (n = 32)	30 (94, 79-99)	22 (69, 50-84)	3 (9, 2-25)	12 (38, 21-56)	0 (0, 0-7)	1 (3, 1-21)	2 (6, 0-15)	0 (0, 0-7)	0 (0, 0-7)	0 (0, 0-7)	1 (3, 0-16)
Case-Control (n = 14)	14 (100)	8 (57, 29-82)	1 (7, 0-34)	2 (14, 2-43)	0 (0, 0-15)	3 (21, 5-51)	2 (14, 2-43)	2 (14, 2-43)	1 (7, 0-34)	0 (0, 0-15)	0 (0, 0-15)
Case Series (n = 14)	14 (100)	1 (7, 0-34)	1 (7, 0-34)	1 (7, 0-34)	1 (7, 0-34)	1 (7, 0-34)	0 (0, 0-15)	0 (0, 0-15)	0 (0, 0-15)	0 (0, 0-15)	0 (0, 0-15)
Quasi-Experimental (n = 1)	1 (100)	1 (100)	1 (100)	1 (100)	0 (0, 0-90)	0 (0, 0-90)	0 (0, 0-90)	0 (0, 0-90)	0 (0, 0-90)	0 (0, 0-90)	0 (0, 0-90)
Economic & Decision Analyses (n = 1)	1 (100)	0 (0, 0-90)	0 (0, 0-90)	0 (0, 0-90)	0 (0, 0-90)	0 (0, 0-90)	0 (0, 0-90)	0 (0, 0-90)	0 (0, 0-90)	0 (0, 0-90)	0 (0, 0-90)
Stratified by Sport & Exercise											
General Population Exercise (n = 81)	79 (98, 91-100)	77 (95, 88-99)	13 (16, 9-26)	27 (33, 23-45)	1 (1, 0-7)	35 (43, 32-55)	9 (11, 5-20)	11 (14, 7-23)	2 (2, 0-9)	2 (2, 0-9)	4 (5, 1-12)
Multiple Sports (n = 57)	54 (95, 85-99)	27 (47, 34-61)	0 (0, 0-4)	8 (14, 6-26)	0 (0, 0-4)	8 (14, 6-26)	4 (7, 2-17)	2 (4, 0-12)	1 (2, 0-9)	1 (2, 0-9)	2 (4, 0-12)

Table continues on next page.

APPENDIX B (CONTINUED)

	Conflict of Interest	Funding	Data Citation	Data Transparency	Analysis & Code Transparency	Materials & Methods Transparency	Reporting Guideline	Study Registration	Study Protocol	Analysis Plan	Patient & Public Involvement
General Orthopaedic Patients (n = 51)	50 (98, 89-100)	23 (45, 31-60)	2 (4, 1-13)	3 (6, 1-16)	1 (2, 0-10)	8 (16, 7-29)	8 (16, 7-29)	9 (18, 24-52)	3 (6, 1-16)	1 (2, 0-10)	0 (0, 0-4)
Running (n = 15)	15 (100)	15 (100)	0 (0, 0-14)	5 (33, 12-62)	0 (0, 0-14)	7 (47, 21-73)	1 (7, 0-32)	1 (7, 0-32)	0 (0, 0-14)	0 (0, 0-14)	0 (0, 0-14)
Baseball (n = 10)	10 (100)	0 (0, 0-21)	1 (10, 0-45)	0 (0, 0-21)	0 (0, 0-21)	4 (40, 12-74)	0 (0, 0-21)	0 (0, 0-21)	0 (0, 0-21)	0 (0, 0-21)	0 (0, 0-21)

All data are reported as count (%, 95% confidence interval). Replication is not shown as no studies performed a replication.
Abbreviations: AJSM, American Journal of Sports Medicine; BJSM, British Journal of Sports Medicine; JSHS, Journal of Sport and Health Science; MSSE, Medicine and Science in Sports and Exercise; RCT, randomized controlled trial.