



# The sex gap in sports and exercise medicine research: who does research on females?

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## Abstract

Females are underrepresented in sports and exercise medicine research, both as authors and as research participants. The aim of this study was therefore to explore who does sports and exercise medicine research on females. All original research articles with female-only samples published in six major sports and exercise medicine journals over a 7-year period (2014–2020;  $n = 334$ ) were examined. Out of the 2027 authors of the articles in question, 1149 were categorized as male (56.7%) and 850 were categorized as female (41.9%; 28 [1.4%] could not be categorized). A slight majority of the articles had a female as first author (51.5%), while the majority of the last authors were male (62.3%). Binomial tests of proportions revealed that females were overrepresented in all author roles in this sample compared to the field at large, while chi-square tests of proportions indicated minimal variations in female authorship across the studied period. These findings indicate that females are relatively more likely to do research on females than males are, and that the rate of female authorship remained relatively constant over time.

**Keywords** Authorship · Gender bias · Leaky pipeline · Senior author · Sex bias

## Introduction

The underrepresentation of female participants in sports and exercise medicine, and the adverse effect this sex gap can have, has garnered some attention in recent years (Costello et al., 2014; Cowley et al., 2021; Emmonds et al., 2019; Hagstrom et al., 2021; Hutchins et al., 2021; Mujika & Taipale, 2019; Smith et al., 2022b; Zhu et al., 2022). The underrepresentation of females as authors in the same field has also been investigated recently, revealing that females only make up a fraction of total authorship (Dynako et al., 2020; Martínez-Rosales et al., 2021). However, the intersection of female participants and female authors in sports and exercise medicine has not been explored yet.

Previous research on representation in science has shown how consequential author diversity can be, and how the composition of the author team can affect how the research is carried out and which topics are explored (Asserson & Janis, 2022; Risi et al., 2022; Xiao

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et al., 2018; Yang et al., 2022). Indeed, female authors in medical and surgical research have been found to be more likely to include female participants in their studies (Xiao et al., 2018) and explore topics related to sex and gender (Nielsen et al., 2017; Sugimoto et al., 2019). There is ample reason to assume the same applies in sports and exercise medicine.

While females are still a minority in sports and exercise medicine, female authorship has increased steadily in recent years (Dynako et al., 2020; Martínez-Rosales et al., 2021). Seeing as demographic changes in some research fields have been shown to coincide with increased diversification in the types of questions being asked and the methodologies being applied (Risi et al., 2022), one would expect the increase in female authorship to affect the research output.

Consequently, the aim of this study was twofold. Firstly, to examine who does research on females within sports and exercise medicine and determine whether females are over- or underrepresented in this category compared to the field in general. And secondly, to examine whether there were any variations in authorship over time. In light of previous findings, females were expected to be overrepresented when it came to overall authorship, first authorship and last authorship, while female authorship was expected to rise across time.

## Methods

### Data and procedure

This study built upon the work of Cowley et al. (2021), who examined the ratio of male and female participants in six prominent sports and exercise medicine journals during the period from 2014 to 2020 (the European Journal of Sports Science, Medicine & Science in Sport & Exercise, the American Journal of Sports Medicine, the British Journal of Sports Medicine, the Journal of Sport Science & Medicine, and the Journal of Physiology). This study analyzed all research from the aforementioned journals during the period in question with a female-only sample. A total of 334 studies, authored by 2027 authors ( $M=6.07$ ,  $SD=2.62$ ), and an aggregated sample of 230,290 participants ( $M=689.58$ ,  $SD=5327.48$ ).

The process of classifying sex was done manually using the authors' names which were collected from the journals' websites. Various tools including photographs, Google Scholar, ResearchGate, institutional profiles, personal websites and social media were used. If there was any ambiguity concerning the authors' sex it was categorized as unknown and excluded from the analysis. As the information was freely available and part of the public domain, no ethical approval was needed, and no informed consent was obtained.

### Statistical analysis

Means and standard deviations were calculated for continuous data while categorical data were presented using percentages. Binomial tests of proportions were performed to determine whether female authors were overrepresented within the sample. The study sample was tested against an estimation of female authors in the field established by Martínez-Rosales et al., (2021; overall proportion of female authors=25.5%, proportion of female first authors=24.8%, proportion of female last authors 16.8%). Chi-square tests of proportions were performed to assess variation in female authorship during the studied period. All statistical analyses were performed using IBM SPSS Statistics (Version 28) with statistical significance accepted at  $p < 0.05$ .

## Results

Out of the 2027 authors, 850 were categorized as female (41.9%) and 1149 were categorized as male (56.7%). Twenty-eight authors (1.4%) could not be categorized as sufficient information was not available online. The majority of research articles were sex diverse (78.7%), but 13.2% were all-male and 8.1% were all-female. Fifty-one-point-five percent of the studies had female first authors, 47% of the studies had male first authors and 1.5% of the first authors could not be categorized. Thirty-six-point-eight percent of the last authors were female, and 61.7% were male, while 0.6% could not be categorized. An overview of female authorship by year of publication can be seen in Table 1 below.

The results of the binomial tests of proportions indicated that females were overrepresented in this sample compared to the field in general on all accounts; across all authors (41.9% vs. 25.5%,  $p < 0.001$ ), first authors (51.5% vs. 24.8%,  $p < 0.001$ ) and last authors (36.8% vs. 16.8%,  $p < 0.001$ ). The chi-square tests of proportions indicated no statistically significant variation across the 7-year period for total female authorship ( $X^2 [6] = 3.9$ ,  $p = 0.696$ ), or female first authorship ( $X^2 [6] = 7.9$ ,  $p = 0.247$ ), but did indicate a statistically significant variation in last authorship ( $X^2 [6] = 25.5$ ,  $p < 0.001$ ) that appears to trend downward.

## Discussion

This study appears to be the first to examine authorship on studies with all-female samples within the field of sports and exercise medicine. The results provide clear evidence of an overrepresentation of female authors compared to their prevalence in the field as a whole, both as a share of overall authorship and in the more prestigious first- and last authorship roles. Seeing as the studied sample is quite unique, the results are incongruent with the results of other studies exploring sex and authorship (Barrios et al., 2013; Dynako et al., 2020; Holman et al., 2018; Martínez-Rosales et al., 2021; Webb et al., 2021; Xiao et al., 2018). These findings indicate that female authors are more likely than male authors to both carry out and be involved in studies on all-female samples.

While females were the first author on just over half of all included publications, males are still in the majority when it comes to last authorship. The last authorship position is traditionally given to the most senior researcher involved in the research project and often entails a supervisory or administrative role. This sex gap between first- and last authorship is in line with previous bibliographical studies in sports and exercise medicine (Dynako et al., 2020; Martínez-Rosales et al., 2021), and elsewhere (Nielsen et al., 2017; Webb et al., 2021).

While there are several factors that can explain this sex gap in first- and last authorship, the two that appear to have the most explanatory power are demographic inertia and sex-differences in post-graduation retention in academia; colloquially referred to as the leaky pipeline (Shaw & Stanton, 2012). Demographic inertia refers to the time it takes for demographic shifts to work their way up the hierarchy (i.e., females have traditionally been underrepresented and even though they have passed males in some fields it will take time for all those females to achieve seniority), while the leaky pipeline refers to the fact that females tend to face more challenges during their career development than males, which lead to them being more likely to leave academia and have shorter academic careers

**Table 1** An overview of female authorship by year of publication

	2014	2015	2016	2017	2018	2019	2020
Average female authorship ( <i>M</i> [ <i>SD</i> ])	2.48 (1.92)	2.71 (1.95)	2.69 (1.8)	2.53 (1.77)	2.00 (1.59)	2.57 (2.14)	2.63 (1.91)
Female authors (%)	48.4	44.9	44.1	38.9	32.3	39.9	41.7
Female first authors (%)	55.7	58.5	59.3	48.3	42.3	38.9	55.0
Female last authors (%)	41	58.5	33.3	34.5	19.2	38.9	27.5

than their male counterparts (Huang et al., 2020; Llorens et al., 2021; Moss-Racusin et al., 2012; Pinho-Gomes et al., 2021). Female academics have also been found to be less likely to hold keynote speeches (Klein et al., 2017) and sit on conference panels (Teoh et al., 2021) and editorial boards (Martínez-Rosales et al., 2021; Pinho-Gomes et al., 2021), in addition to receiving fewer invitations to write papers (Holman et al., 2018) and receiving disproportionately fewer awards (Silver et al., 2017). However, recent findings indicate that the pipeline may not be as leaky everywhere, with career progression being more egalitarian in Norway than in the United States (Aksnes et al., 2022).

The underrepresentation of female authors in sports and exercise medicine research may not be inherently problematic, seeing as the quality of the research should always be more important than the identity of the authors. However, if the lack of diversity in authorship leads to a lack of research diversity, authorship diversity becomes a problem. Because if the evidence-base for evidence-informed practice has mostly been extrapolated from research on male participants, without considering the potential influences of sexual dimorphisms, the health and well-being of females can be threatened (Emmonds et al., 2019; Smith et al., 2022b; Zhu et al., 2022). Any meaningful and credible recommendations regarding females should therefore be based on research that accounts for the numerous anatomical- and biological differences that exist between the sexes (Smith et al., 2022a, b). Additionally, previous research on authorship has also revealed that sex-diverse author teams have greater reach and produce more novel research than same-sex authors teams, adding further incentives to increase the diversity of co-authorship (Does et al., 2018; Yang et al., 2022).

No variations were observed in total female authorship or female first authorship during the studied period. However, there appeared to be a slight downward trend in female last authorship across time. While this trend can be interpreted in a myriad of ways, an optimistic interpretation from a diversity perspective would be that senior male researchers are increasingly opting to study female samples and feminine subject matter. If that interpretation is true, senior male researchers may be acknowledging that the burden of closing the sex gap in author should not fall solely on the shoulders of females. These findings are incongruent with the findings of Dynako et al. (2020) who found the rate of female authorship in sports and exercise medicine to increase substantially over time; however, their study spanned a significantly longer period and covers heterogeneous samples. The same applies to the findings of Martínez-Rosales et al. (2021) who found an increase in female first authorship but not female last authorship during a 20-year period.

## Limitations and future directions

The results of this study should be viewed with its limitations in mind. Only six journals were examined, possibly skewing the results. These six journals all have a relatively high impact factor and may not be representative for the field as a whole. However, seeing as female authors have been found to be underrepresented in high impact journals (Holman et al., 2018), the results are more likely to under- than over-estimate female authorship. These journals were chosen as they have previously been the focal point of sex-bias research in the field of sports and exercise medicine (Costello et al., 2014; Cowley et al., 2021). It should also be noted that last authorship is not a perfect surrogate for seniority, and some of the last authors may have been placed there on different grounds. Co-first and co-last authorships were not considered.

Classifying the sex of the authors manually should be considered a strength. Compared to many other bibliographical studies where sex is assigned using an automated process

(i.e., an algorithm), the rate of unknown authors is relatively low, and so is the probability of errors. However, this process also limits the scope of the study, seeing as manual classification is immensely labor intensive.

While the socially constructed term gender is more traditionally used in the bibliometric literature, the biological term sex was chosen in this study as it is the preferred term in sports and exercise medicine research. The same goes for the associated terms man/woman/non-binary, and male/female. This decision was deliberate and made based on sex being the appropriate term when discussing the practical implications of the sex-gap in participant recruitment. Using the terms sex and gender interchangeably was considered undesirable seeing as there are important distinctions between the two. There may also be a mismatch between the gender one associates with and the sex one was assigned at birth.

Future studies should assess whether the study's findings are representative for the field of sports and exercise medicine as a whole, and whether they apply to other related fields. Other possible differences related to the authors' sex and the composition of the author team should also be explored (e.g., themes and methodology).

## Conclusion

The results of this study indicate that female authors are relatively more likely than male authors to lead and carry out research on all-female samples. While these findings may not be particularly surprising, and were indeed in line with findings from related fields, they may offer an interesting explanation as to why females and feminine subject matters are relatively sparse in sports and exercise medicine. If the sex-gap in participant recruitment is to be narrowed further, we can't wait passively for the demographic inertia in academia to catch up, because even though females are a minority in academia, they are still half of the (active) population and their reality should be explored to the same extent as males'.

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**Data availability** Data is openly available at <https://doi.org/10.6084/m9.figshare.20444082.v1>.

## Declarations

**Conflict of interest** The author has no conflicting interests to report.

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## References

- Aksnes, D. W., Kahn, S., Reiling, R. B., & Ulvestad, M. E. (2022). Longitudinal evidence on Norwegian PhDs suggests slower progression for women academics but not a leaky pipeline. *SocArXiv*. <https://doi.org/10.31235/osf.io/vpx8q>
- Asserson, D. B., & Janis, J. E. (2022). Does diversity of authorship matter? An analysis of plastic surgery's top 100 articles. *Plastic and Reconstructive Surgery Global Open*, 10(3), e4214. <https://doi.org/10.1097/GOX.00000000000004214>
- Barrios, M., Villarroya, A., & Borrego, Á. (2013). Scientific production in psychology: A gender analysis. *Scientometrics*, 95(1), 15–23. <https://doi.org/10.1007/s11192-012-0816-4>
- Costello, J. T., Bieuzen, F., & Bleakley, C. M. (2014). Where are all the female participants in sports and exercise medicine research? *European Journal of Sport Science*, 14(8), 847–851. <https://doi.org/10.1080/17461391.2014.911354>
- Cowley, E. S., Olenick, A. A., McNulty, K. L., & Ross, E. Z. (2021). “Invisible sportswomen”: The sex data gap in sport and exercise science research. *Women in Sport and Physical Activity Journal*, 29(2), 146–151. <https://doi.org/10.1123/wspaj.2021-0028>
- Does, S., Ellemers, N., Dovidio, J. F., Norman, J. B., Mentovich, A., van der Lee, R., & Goff, P. A. (2018). Implications of research staff demographics for psychological science. *American Psychologist*, 73(5), 639. <https://doi.org/10.1037/amp0000199>
- Dynako, J., Owens, G. W., Loder, R. T., Frimpong, T., Gerena, R. G., Hasnain, F., Snyder, D., Freiman, S., Hart, K., & Kacena, M. A. (2020). Bibliometric and authorship trends over a 30 year publication history in two representative US sports medicine journals. *Heliyon*, 6(3), e03698. <https://doi.org/10.1016/j.heliyon.2020.e03698>
- Emmonds, S., Heyward, O., & Jones, B. (2019). The challenge of applying and undertaking research in female sport. *Sports Medicine-Open*, 5(1), 1–4. <https://doi.org/10.1186/s40798-019-0224-x>
- Hagstrom, A. D., Yuwono, N., Warton, K., & Ford, C. E. (2021). Sex bias in cohorts included in sports medicine research. *Sports Medicine*, 51(8), 1799–1804. <https://doi.org/10.1007/s40279-020-01405-6>
- Holman, L., Stuart-Fox, D., & Hauser, C. E. (2018). The gender gap in science: How long until women are equally represented? *PLoS Biology*, 16(4), e2004956. <https://doi.org/10.1371/journal.pbio.2004956>
- Huang, J., Gates, A. J., Sinatra, R., & Barabási, A.-L. (2020). Historical comparison of gender inequality in scientific careers across countries and disciplines. *Proceedings of the National Academy of Sciences*, 117(9), 4609–4616. <https://doi.org/10.1073/pnas.1914221117>
- Hutchins, K. P., Borg, D. N., Bach, A. J., Bon, J. J., Minett, G. M., & Stewart, I. B. (2021). Female (under) representation in exercise thermoregulation research. *Sports Medicine-Open*, 7(1), 1–9. <https://doi.org/10.1186/s40798-021-00334-6>
- Klein, R. S., Voskuhl, R., Segal, B. M., Dittel, B. N., Lane, T. E., Bethea, J. R., Carson, M. J., Colton, C., Rosi, S., & Anderson, A. (2017). Speaking out about gender imbalance in invited speakers improves diversity. *Nature Immunology*, 18(5), 475–478. <https://doi.org/10.1038/ni.3707>
- Llorens, A., Tzovara, A., Bellier, L., Bhaya-Grossman, I., Bidet-Caulet, A., Chang, W. K., Cross, Z. R., Dominguez-Faus, R., Flinker, A., & Fonken, Y. (2021). Gender bias in academia: A lifetime problem that needs solutions. *Neuron*, 109(13), 2047–2074. <https://doi.org/10.1016/j.neuron.2021.06.002>
- Martínez-Rosales, E., Hernández-Martínez, A., Sola-Rodríguez, S., Esteban-Cornejo, I., & Soriano-Maldonado, A. (2021). Representation of women in sport sciences research, publications, and editorial leadership positions: Are we moving forward? *Journal of Science and Medicine in Sport*, 24(11), 1093–1097. <https://doi.org/10.1016/j.jsams.2021.04.010>
- Moss-Racusin, C. A., Dovidio, J. F., Brescoll, V. L., Graham, M. J., & Handelsman, J. (2012). Science faculty's subtle gender biases favor male students. *Proceedings of the National Academy of Sciences*, 109(41), 16474–16479. <https://doi.org/10.1073/pnas.1211286109>
- Mujika, I., & Taipale, R. S. (2019). Sport science on women, women in sport science. *International Journal of Sports Physiology and Performance*, 14(8), 1013–1014. <https://doi.org/10.1123/ijsspp.2019-0514>
- Nielsen, M. W., Andersen, J. P., Schiebinger, L., & Schneider, J. W. (2017). One and a half million medical papers reveal a link between author gender and attention to gender and sex analysis. *Nature Human Behaviour*, 1(11), 791–796. <https://doi.org/10.1038/s41562-017-0235-x>
- Pinho-Gomes, A.-C., Vassallo, A., Thompson, K., Womersley, K., Norton, R., & Woodward, M. (2021). Representation of women among editors in chief of leading medical journals. *JAMA Network Open*, 4(9), e2123026–e2123026. <https://doi.org/10.1001/jamanetworkopen.2021.23026>
- Risi, S., Nielsen, M. W., Kerr, E., Brady, E., Kim, L., McFarland, D. A., Jurafsky, D., Zou, J., & Schiebinger, L. (2022). Diversifying history: A large-scale analysis of changes in researcher demographics and scholarly agendas. *PLoS ONE*, 17(1), e0262027. <https://doi.org/10.1371/journal.pone.0262027>

- Shaw, A. K., & Stanton, D. E. (2012). Leaks in the pipeline: Separating demographic inertia from ongoing gender differences in academia. *Proceedings of the Royal Society b: Biological Sciences*, 279(1743), 3736–3741. <https://doi.org/10.1098/rspb.2012.0822>
- Silver, J. K., Slocum, C. S., Bank, A. M., Bhatnagar, S., Blauwet, C. A., Poorman, J. A., Villablanca, A., & Parangi, S. (2017). Where are the women? The underrepresentation of women physicians among recognition award recipients from medical specialty societies. *Pm&r*, 9(8), 804–815. <https://doi.org/10.1016/j.pmrj.2017.06.001>
- Smith, E. S., McKay, A. K., Ackerman, K. E., Harris, R., Elliott-Sale, K. J., Stellingwerff, T., & Burke, L. M. (2022a). Methodology review: A protocol to audit the representation of female athletes in sports science and sports medicine research. *International Journal of Sport Nutrition and Exercise Metabolism*, 32(2), 114–127. <https://doi.org/10.1123/ijsem.2021-0257>
- Smith, E. S., McKay, A. K., Kuikman, M., Ackerman, K. E., Harris, R., Elliott-Sale, K. J., Stellingwerff, T., & Burke, L. M. (2022b). Auditing the representation of female versus male athletes in sports science and sports medicine research: Evidence-based performance supplements. *Nutrients*, 14(5), 953. <https://doi.org/10.3390/nu14050953>
- Sugimoto, C. R., Ahn, Y.-Y., Smith, E., Macaluso, B., & Larivière, V. (2019). Factors affecting sex-related reporting in medical research: A cross-disciplinary bibliometric analysis. *The Lancet*, 393(10171), 550–559. [https://doi.org/10.1016/S0140-6736\(18\)32995-7](https://doi.org/10.1016/S0140-6736(18)32995-7)
- Teoh, J.Y.-C., Castellani, D., Mercader, C., Sierra, A., Heldwein, F. L., Chan, E.O.-T., Wroclawski, M. L., Sepulveda, F., Cacciamani, G. E., & Rivas, J. G. (2021). A quantitative analysis investigating the prevalence of “manels” in major urology meetings. *European Urology*, 80(4), 442–449. <https://doi.org/10.1016/j.eururo.2021.05.031>
- Webb, J., Cambron, J., Xu, K. T., Simmons, M., & Richman, P. (2021). First and last authorship by gender in emergency medicine publications—a comparison of 2008 vs. 2018. *The American Journal of Emergency Medicine*, 46, 445–448. <https://doi.org/10.1016/j.ajem.2020.10.045>
- Xiao, N., Mansukhani, N. A., de Oliveira, D. F. M., & Kibbe, M. R. (2018). Association of author gender with sex bias in surgical research. *JAMA Surgery*, 153(7), 663–670. <https://doi.org/10.1001/jamasurg.2018.0040>
- Yang, Y., Tian, T. Y., Woodruff, T. K., Jones, B. F., & Uzzi, B. (2022). Gender-diverse teams produce more novel and higher-impact scientific ideas. *Proceedings of the National Academy of Sciences*, 119(36), e2200841119. <https://doi.org/10.1073/pnas.2200841119>
- Zhu, J. W., Reed, J. L., & Van Spall, H. G. (2022). The underrepresentation of female athletes in sports research: Considerations for cardiovascular health. *European Heart Journal*. <https://doi.org/10.1093/eurheartj/ehab846>