Gender Differences in Physical Activity and Health-Related Authorships Between 1950 and 2019

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Background: The objective of this study was to investigate gender differences in authorship in physical activity and health research. Methods: A bibliometric study including 23,399 articles from 105 countries was conducted to estimate the participation of female researchers in physical activity publications from 1950 to 2019. The frequency of female researchers was analyzed and classified by first and last authors and the overall percentage of female authors by region and country. Results: The proportion of female first authors increased from <10% in the 50s and 80s to 55% in the last decade. On the other hand, the proportion of last authors increased from 8.7% to 41.1% in the same period. Most publications with female researchers were from the United States, Canada, Australia, Brazil, the Netherlands, Spain, England, Germany, Sweden, and China. Nine of these countries had over 50% of the articles published by female first authors. However, in all 10 countries, <50% of the articles were published by female last authors. Conclusions: The proportion of female researchers increased over time. However, regional differences exist and should be addressed in gender equity policies. There is a gap in the participation of female researchers as last authors. By actively addressing the gender gap in research, the global society can harness the full potential of all talented individuals, regardless of gender, leading to more inclusive and impactful scientific advancements.

Keywords: bibliometrics, motor activity, gender equity, female authorship, women in academia

The gender gap in research refers to the underrepresentation and unequal treatment of women in various fields of scientific research. Despite significant progress in recent decades,¹ gender disparities persist in terms of representation, recognition, career advancement, funding opportunities, and decision-making positions within the research community.

Achieving gender equity is a complex challenge that should be set as one of the most important health and economic development priorities around the globe.² Gender inequality affects health and social outcomes, such as bias in science, interpersonal violence against women, anxiety, and stress.² Academia is not exempt from the gender gap in research authorship. Even in countries in Central Asia and Latin America, which concentrate the highest regional prevalence of female researchers, the proportion of female researchers is still below 50%.³ This gap is wider in other countries, with women representing less than a fifth of the total number of researchers in South and West Asia.³

The participation of women in science contributes to the quality of the research by considering issues such as women’s health regarding bias in fertility studies.⁴ Research groups of both genders are considered more effective and productive than groups of 1 gender only, mainly in the science and engineering areas.⁵,⁶ Diversity is a key factor in creating more successful research groups.⁷,⁸ Although gender diversity has increased over the past decades among graduate students, women remain underrepresented in academic leadership.⁹,¹⁰ This problem reflects the difficulty women face in ascending to leadership positions within groups, and gender disparities can be found in wage discrimination, academic publications, and citations.¹⁰

The gender gap in research is a complex and multifaceted issue with several key aspects. First, women are often underrepresented in scientific disciplines,¹¹,¹² which can hinder diversity and limit perspectives in research. Second, women face difficulties in career

Key Points
- The representation of female researchers in the physical activity literature has steadily increased over time.
- Not all women have had equal opportunities to advance to the position of last author in academic publications.
- Women need to move up the ladder to last authors’ positions.
progression, encountering obstacles such as restricted access to leadership positions, lower promotion rates, and limited research funding opportunities.\textsuperscript{13,14} Third, publication and citation bias can negatively impact women researchers as their contributions may be undervalued or overlooked compared with their male counterparts.\textsuperscript{15–17} This disparity in recognition may affect their visibility, reputation, and future career prospects. Fourth, women struggle with work–life balance, particularly during critical career stages like pursuing a PhD or engaging in postdoctoral positions or while starting a family.\textsuperscript{2,18} Finally, gender stereotypes and biases in research settings can hinder women’s progress.\textsuperscript{1,19–20} Preconceived notions about their abilities, commitment, and suitability for certain fields can undermine their confidence and limit access to necessary resources. Addressing these key aspects of the gender gap in research requires comprehensive and concerted efforts to promote inclusivity, eliminate biases, and create supportive environments for women scientists.

Data from the Global Observatory of Physical Activity offer a possibility to address this issue in the context of physical activity research. In 2021, Ramirez-Varela et al\textsuperscript{21} published a systematic review, including articles published in the field of physical activity and health between 1950 and 2019. In the current paper, we apply a gender equity lens for the examination of this physical activity literature. We evaluate women’s participation as first and last authors and the overall participation of women in each publication. These indicators are compared over time (from 1950 to 2019) and across World Health Organization regions.

**Methods**

A bibliometric study was conducted to estimate the participation of female researchers in physical activity publications from 1950 to 2019. This study was approved by the Research Ethics Committee of the Medical School (number 5.400.881) at the Federal University of Pelotas, Brazil (CAAE number 5697/122.4.0000.53/17). A systematic review was conducted in August 2017 and updated in January 2020, including data from PubMed, Scopus, and ISI Web of Knowledge. Search terms were used for (1) “physical activity” in the title and abstract and (2) country name anywhere in the title, abstract, text, or affiliation. The “physical activity” search terms used were the following: physical activity OR physically active OR physical inactivity OR physically inactive OR physical fitness OR exercise * OR walk OR walking OR sedentary OR active transport * OR active transit OR active travel OR commute * OR active commuting OR bicycle OR bicycling OR bike OR biking OR active living OR active-living, and the country name was used in English. More information about the methods of this systematic review can be found in Ramirez-Varela et al.\textsuperscript{21}

The World Bank list of 215 countries was adapted by dividing the United Kingdom into England, Northern Ireland, Scotland, and Wales and combining China and Taiwan as the Greater China Area. The final list resulted in 217 countries grouped by region according to the World Health Organization classification (AFRO—Africa; EMRO—Eastern Mediterranean; EURO—Europe; PAHO—The Americas and the Caribbean; SEARO—South-East Asia; and WPRO—Western Pacific).

For this paper’s analysis, we included the 105 countries with 10 or more articles published between 1950 and 2019 (Albania, Argentina, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Barbados, Belgium, Botswana, Brazil, Bulgaria, Cameroon, Canada, Chile, China, Colombia, Costa Rica, Croatia, Cuba, Cyprus, Czech Republic, Denmark, Ecuador, Egypt, England, Estonia, Ethiopia, Fiji, Finland, France, Georgia, Germany, Ghana, Greece, Guatemala, Hong Kong, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Kosovo, Kuwait, Lebanon, Lithuania, Luxembourg, Malaysia, Mexico, Mongolia, Morocco, Mozambique, Nepal, the Netherlands, New Zealand, Nigeria, North Korea, Northern Ireland, Norway, Oman, Pakistan, Palestine, Peru, Philippines, Poland, Portugal, Puerto Rico, Qatar, Romania, Russian Federation, Saudi Arabia, Scotland, Senegal, Serbia, Singapore, Slovak Republic, Slovenia, South Africa, South Korea, Spain, Sri Lanka, Sweden, Switzerland, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, the United States, Uruguay, Vanuatu, Venezuela, Vietnam, Virgin Islands [the United States], and Wales).

For the present study, the authors of the identified publications were the main unit of analysis. Google Forms was used to create the database with bibliometric variables. References were used to find specific articles in the database using Google Search. Authors were categorized as first, middle, or last authors using the authorship order presented in the paper. The authors were classified as man or woman based on social media, university websites, government websites, and institutional websites. Author’s names that could not be located were described as not identified and excluded. Articles with only one author were considered to have only last authors. The year of publication, region of origin, country name, total number of authors, and number of female authors were collected from each article. The mean percentage of female authors was calculated from the total number of authors and number of female authors.

Data were analyzed using Stata (version 18) for Windows, and tables and figures were created in Microsoft Power BI. The frequency of female researchers was analyzed and classified by first, senior, and the overall percentage of female authors by region and country. Descriptive analyses for decades were conducted to identify publication patterns according to the author’s gender. T test and Mann–Whitney U tests were used to determine

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Descriptive Analyses of the Articles on Physical Activity and Health (1950–2019) by World Health Organization Regions</th>
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</thead>
<tbody>
<tr>
<td>Region</td>
<td>AFRO</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Total articles, N (%)</td>
<td>453 (1.9)</td>
</tr>
<tr>
<td>Female first author, n (%)</td>
<td>179 (40.7)</td>
</tr>
<tr>
<td>Female senior author, n (%)</td>
<td>151 (33.4)</td>
</tr>
<tr>
<td>Mean percentage of female authors, %</td>
<td>38.5 (42.5)</td>
</tr>
</tbody>
</table>

Abbreviations: AFRO, African Region; EMRO, Eastern Mediterranean Region; EURO, Europe Region; PAHO, Pan American Health Organization; SEARO, South-East Asia Region; WPRO, Western Pacific Region. Note: World Region is based on the division of the World Health Organization’s regional offices.
Figure 1 — Proportion of female first author and female senior author by region and decade in physical activity and health research by decade between 1950 and 2019. AFRO indicates African Region; EMRO, Eastern Mediterranean Region; EURO, Europe Region; PAHO, Pan American Health Organization; SEARO, South-East Asia Region; WPRO, Western Pacific Region.
significant differences between female and male authors. Poisson regression was used to test time trends using “decades” as a covariate. A significance level of .05 was adopted for statistical tests.

Results

The literature review included 23,860 articles, of which 23,399 were included in the analytical sample for this manuscript. We could not identify the gender of the first author in 61 articles (0.3%) and the last author in 62 (0.3%) articles. In addition, there were 682 (2.9%) articles with only one author. Table 1 describes the sample of articles by region of origin.

Of 22,656 papers, 12,541 (55.3%) had a female first author. The proportion of articles with a female last author was 39.5%. Articles with a female last author presented a lower number of coauthors than those with male last authors (5.5 vs 6.1, \(P < .001\)). PAHO was the region with the highest percentage of female first and last authors, whereas AFRO was the region with the lowest equivalent percentages.

The proportion of female first authors was below 30% in 6 countries (Senegal, Nigeria, Kuwait, Ethiopia, Cameroon, and Bangladesh). The proportion of female last authors was below 30% in 34 countries (Austria, Azerbaijan, Bangladesh, Botswana, Cameroon, Chile, Cyprus, Ethiopia, Fiji, France, Germany, Greece, Guatemala, Iceland, Italy, Japan, Kenya, Kuwait, Mozambique, Nigeria, Pakistan, Palestine, Peru, Portugal, Russian Federation, Saudi Arabia, Slovenia, Sri Lanka, Tunisia, Uganda, Ukraine, Uruguay, Vanuatu, and Vietnam).

The proportion of female first authors was above 70% in 9 countries (Barbados, Belgium, Oman, Russian Federation, Slovak Republic, Tunisia, Vanuatu, Virgin Islands, and Wales). The proportion of female last authors was above 70% in 4 countries (Virgin Islands, Trinidad and Tobago, Georgia, and Barbados).

Nine of the 10 countries with the most publications (the United States, Canada, Australia, Brazil, the Netherlands, Spain, England, Germany, Sweden, and China) had >50% of the articles published by female first authors. However, all top 10 countries had <50% of the articles published by female last authors.

Figure 1 shows that the number of female first authors increased significantly by decade in EURO, PAHO (\(P < .001\)), and WPRO (\(P = .05\)). This increase was not significant in AFRO, EMRO, and SEARO. The proportion of female last authors increased significantly in the same regions (EURO, PAHO, and WPRO).

The mean percentage of female authors per article increased during the studied decades worldwide (Figure 2). Between 1950 and 1979, female researchers represented 8.7% of the total authors, increasing each decade afterward and reaching 48.8% between 2010 and 2019 (\(P < .001\)). Figure 3 shows that only in the AFRO and SEARO regions was the increase per decade not statistically significant (\(P = .5\) and \(P = .3\), respectively).

Discussion

In this paper, we evaluate women’s participation as first and last authors and the overall participation of women in each publication in the field of physical activity research. These indicators are compared over time (from 1950 to 2019) and across World Health Organization regions. Our findings indicate a steady increase in the percentage of female researchers in physical activity publications in most world regions. However, the percentage of female first authors is higher than that of female last authors worldwide. This finding is observed in the 10 countries with the most publications; none presented more women than men as last author, but 9 presented more women than men as first author.

First authors are usually defined as those who make the greatest contributions, whereas last authors are usually defined
Figure 3 — Mean percentage of female authors by region and decade in physical activity and health research. AFRO indicates African Region; EMRO, Eastern Mediterranean Region; EURO, Europe Region; PAHO, Pan American Health Organization; SEARO, South-East Asia Region; WPRO, Western Pacific Region.
as principal investigators. Based on our analysis, women are still the minority as last authors in physical activity and health publications but are the majority of first authors. This result brings positive and negative aspects. First, we value that the field of physical activity and health achieved equity in first authorships. However, not all women have been able to move up the ladder to last authors’ positions. For example, for the EMRO region, it has taken >3 decades to see the work of women as mentors reflected. More broadly, the last author position remains largely with male authors despite the rise of women as 

Authors.

More broadly, the last author position remains largely with male authors despite the rise of women as first authors in medical science. In science, technology, engineering and mathematics (STEM), women experience a series of prejudices that impose barriers to acting under the same conditions as their male peers. These gender differences in authorship order of the articles must not discourage young female researchers from doing research. Contrarily, it should help engage the global community in the gender equity conversation at all levels.

Another interesting finding is the lower mean number of coauthors in papers in which the last author is a female researcher. This result is in line with the notion that women may have more difficulty carrying out scientific research for multiple reasons, like difficulties in accessing the educational system, housework and care, access to employment, or little collaboration between research groups. For example, when researchers have less collaboration, they have fewer chances of forming networks; also, studies tend to be more cited when having more authors. In essence, gender equity not only fosters fairness and equality but also amplifies the caliber of research and health care practices. By embracing inclusivity and guaranteeing equal opportunities, we can unleash the complete potential of researchers and health care providers, ultimately paving the way for groundbreaking discoveries.

On the positive side, there was an evolution in gender equity during the period studied. Gender inequality in research is a historical factor causing mistaken beliefs about women’s role in society. At least in the field of physical activity and health, these gaps are narrowing over time, which may be associated with the entry of other areas into physical activity research, such as psychology, nutrition, and medicine. However, more measures to support diversity should be implemented, such as promoting diversity and inclusion, creating mentoring and support programs, generating adequate policies for families, dealing with prejudices and stereotypes, and promoting equal opportunities.

We were unable to move beyond gender in this analysis, which could lead to misclassification. Getting information on authors’ gender might be possible for recent publications, but it is certainly not doable for our analysis that included articles published between 1950 and 2019. We recognize that gender inequalities may exist in physical activity and health research, which should be addressed in further studies. Finally, only studies with abstracts in English, Portuguese, and Spanish were included, leading to a possible underrepresentation of researchers who do not publish in these languages.

In terms of strengths, we reviewed a large database of articles on physical activity and health. Articles from all countries with >10 publications between 1950 and 2019 were analyzed, and we were able to study time trends in each of the 3 indicators related to female participation in research over 70 years.

In conclusion, the representation of female researchers in the physical activity literature has steadily increased over time in some regions, especially in the last 2 decades. Currently, women account for more than half of the first-authored publications in this field. However, there remains a notable disparity when it comes to the participation of female researchers as last authors. It is crucial to address these regional differences and implement gender equity policies, including promoting gender equity in research funding and encouraging women’s leadership in science. Achieving gender diversity in research requires collective action from all stakeholders.

Call for Action

Addressing the gender gap in research requires comprehensive efforts from academic institutions, funding agencies, policymakers, stakeholders, and the scientific community. Some strategies to promote gender equity in research include:

1. Promoting diversity and inclusion: Implementing policies and practices that foster diversity, equity, and inclusion, including gender-balanced recruitment and evaluation processes,

2. Mentoring and support programs: Establishing mentoring programs and support networks that provide guidance, career development opportunities, and work-life balance support for women in research,

3. Family-friendly policies: Implementing family-friendly policies, such as parental leave, flexible working arrangements, and affordable childcare options to support women in balancing their professional and personal responsibilities,

4. Addressing biases and stereotypes: Raising awareness about unconscious biases, promoting bias-free evaluation processes, and challenging gender stereotypes and discrimination within research environments,

5. Promoting equal opportunities: Ensuring equal access to resources, research funding, conference presentations, and leadership positions for women in research.

By actively working toward gender equity in physical activity and health research, the field can benefit from diverse perspectives, creative and innovative approaches, and enhanced research outcomes. It is especially important to develop avenues for senior female researchers and provide incentives to continue with leadership positions in the field. Only through concerted action can we bridge the gender gap and create a more inclusive and equitable physical activity and health research community.

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Authorship in Physical Activity Research

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