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Women authorship in radiology research in France: An analysis of the last three decades

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Abstract
Purpose: The aim of this study was to evaluate the evolution of women authorship in France and to analyze the recent trends of the evolution of gender differences in French academic radiology.
Materials and methods: A retrospective bibliometric analysis was performed by searching for articles published in Diagnostic and Interventional Imaging (Diagn Interv Imaging) and in *Journal de Radiologie* (J Radiol) in Pubmed over the last three decades. For each of these articles, we determined the gender of the first and last author. The specific radiological field of each article was also determined.
Results: The proportion of women authors has significantly increased from 12% in 1984 to 34% in 2014 ($P < 0.0001$) for the first authors and from 11% (11/96) in 1984 to 20% (38/193) in 2014 for last authors ($P = 0.03$).
Conclusion: Women authorship in Diagnostic and Interventional Imaging has increased over the last years together with the proportion of women first authors. However, the fraction of women last authors is still underrepresented. More women need to become leaders in radiological research to contribute to stimulate women authorship.

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There has been a constant increase in the number of women in medical professions worldwide over the past 50 years in most countries [1,2]. There was a dramatic increase in the percentage of women in medicine over the last decades in France. The percentage of women in medicine has increased from 24.5% in 1984 to 43.5% in 2014 [3,4]. The percentage of the women in radiology has also increased, but at a slower rate, with the total percentage of women reaching only 31% in 2014 [4].

However, while the overall increase is constant, with 50% of current French radiology residents being women nowadays [4], men and women have different career paths and aspirations [5]. Fewer women work in private radiology practices (27%) and choose academic careers [3,6].

Since publications in peer-reviewed journals are essential to advancement in academic careers, the trends in authorship may indirectly reflect the evolution of the percentage of women in the academic medical careers [7,8]. While the number of women in medicine increases, many medical journals have found that women authorship is less common than men authorship in several medical specialties [9—11]. Recent publications, which have analyzed the evolution of authorship in some of the major American radiology journals, such as Radiology, and the American Journal of Radiology (AJR), have found a strong increase in women authorship as first authors over the last decades, rising from 20.4% in 1991 to 34.4% in 2013. This trend was similar for most countries submitting to these two journals and namely for France, there was an increase from 21.1% to 36.2% for the same period for female first and corresponding authors [12]. Another study has also shown a significant increase in the percentage of women first authors from 8.33% in 1978 to 32.35% in 2013 and as senior last authors in the team list from 6.75% to 21.90 for the same years in Radiology, AJR and Academic Radiology [13].

Diagnostic and Interventional Imaging (Diagn Interv Imaging) that continued *Journal de Radiologie* (J Radiol)) is the main national radiology journal in France and women authorship in this journal should reflect the contribution of women in academic radiology publications in France.

The aim of the study was to evaluate the evolution of women authorship in France and to analyze the recent trends of the evolution of gender differences in French academic radiology.

Materials and methods

Literature search and data analysis

We have performed a retrospective bibliometric analysis by searching for articles published in Diagn Interv Imaging and in J Radiol in Pubmed over the last three decades in 1984, 1994, 2004 and 2014. For each of these articles, we determined the gender of the first and last author. We determined the gender by analysis of each author's first name. When the first name was not available or could be attributed to either men or women, we performed a google search and/or consulted the authors' institutions. For articles written by a single author, the author was considered to be the first author. We have also determined the specific radiological field of each article. The radiologic subspecialty field of each article was assigned to one of the following categories: abdominal, chest, cardiovascular, interventional, musculoskeletal, neuroradiology and head and neck, pediatric, urinary, women (breast and gynecology) and miscellaneous when the article did not correspond to other categories such as whole-body imaging, physics, basic science, contrast media, management or radiation protection.

The number of women and men as first and last authors in this journal was evaluated for each year. The study has adopted a descriptive research approach by means of bibliometric analysis. The primary outcomes were the gender distributions of the first and last authors. We also calculated the proportions of female authors for each journal during each study period by radiologic subspecialty. For the subspecialty analysis, due to a lower number of articles in the years 1984 and 1994, these years were pooled together. In addition, we examined the association between the gender of the first and last authors.

Statistical analysis

All statistical analyses were performed using JMP8 (SAS) software. Categorical variables were expressed as raw numbers and proportion (%). The chi-square test was used to search for significant increase in women first authorship and association between first author gender and last author gender. A P value < 0.05 was considered to be statistically significant.

Results

Overall, 664 articles were retrieved (125 in 1984, 108 in 1994, 224 in 2004 and 207 in 2014). Out of a total of 1251 first and last authors, the gender of 1189 authors was identified (95%) with 624 first authors and 565 last authors. The remaining 62 authors for whom gender was not identified were excluded from the analysis. For the subspecialty analysis, we have pooled together data from 1984 and 1994 due to a lower number of articles as compared to 2004 and 2014. For the articles that have both first and last authors (615), we have analyzed the relation between the first and last author gender to see if women last authors tended to publish with women first authors.

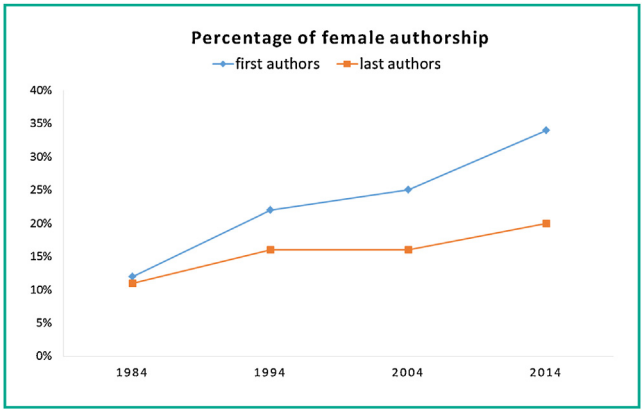

Figure 1. Percentage of female and male authorship from 1984 to 2014 in Diagnostic and Interventional Imaging.

Table 1 Representation of female first and last authors in Diagnostic and Interventional Imaging.

	1984	1994	2004	2014	*P*
Female first author	14/113 (12%)	12/95 (22%)	55/216 (25%)	67/200 (34%)	<0.001
Female last author	11/96 (11%)	14/87 (16%)	30/189 (16%)	38/193 (20%)	0.03

Table 2 Representation of women by radiological specialty among first and last authors in Diagnostic and Interventional Imaging.

	1984 and 1994	2004	2014	*P*
Abdominal				
First author	2/27	18/60	11/39	
Last author	5/27	8/53	1/37	
Total	7/54 (13.9%)	26/113 (23%)	12/75 (16%)	0.75
Chest				
First author	0/7	4/11	8/17	
Last author	2/8	1/12	5/17	
Total	**2/15 (13.3%)**	**5/23 (21.7%)**	**15/34 (44.1%)**	**0.03**
Cardiovascular				
First author	3/10	1/36	3/9	
Last author	0/11	3/27	1/10	
Total	3/21 (14.3)	4/63 (63.5%)	4/19 (21%)	0.56
Interventional				
First author	2/15	1/13	0/20	
Last author	0/13	1/12	1/20	
Total	2/25 (8%)	2/25 (8%)	1/20 (4%)	0.58
Musculoskeletal				
First author	8/42	1/13	7/22	
Last author	5/39	1/13	3/23	
Total	13/81 (16%)	2/26 (7.7%)	10/45 (22.2%)	0.38
Neuroradiology and head and neck				
First author	5/26	3/15	10/26	
Last author	4/23	0/15	9/23	
Total	**9/49 (18.4%)**	**3/30 (10%)**	**19/49 (38.8%)**	**0.02**
Pediatric				
First author	3/10	7/12	6/10	
Last author	1/8	5/12	6/11	
Total	**4/18 (22.2%)**	**12/24 (50%)**	**12/21 (57%)**	**0.02**
Urinary				
First author	9/41	2/21	7/16	
Last author	3/37	0/19	2/15	
Total	12/78 (15.4%)	2/40 (5%)	9/31 (29%)	0.07
Women (breast and gynecology)				
First author	3/9	13/23	13/24	
Last author	3/6	6/19	9/23	
Total	6/15 (40%)	19/42 (45.2%)	22/47 (46%)	0.64
Miscellaneous				
First author	1/21	5/14	2/11	
Last author	1/11	4/9	1/9	
Total	2/32 (6%)	9/23 (39.1%)	3/20 (15%)	0.28

Bold indicates significant differences.

We observed that the proportion of women first authors has significantly increased from 12% (14/113) in 1984 to 34% (67/200) in 2014 ($P < 0.0001$) and from 11% (11/96) in 1984 to 20% (38/193) in 2014 for last authors respectively ($P = 0.03$) (Fig. 1) (Table 1). In 2014, female authorship was highest in chest imaging (44.1%), pediatric radiology (57%), women's imaging (46%) and neuroradiology (38.8%) (Fig. 2) (Table 2). This significant increase over 3 decades has been observed

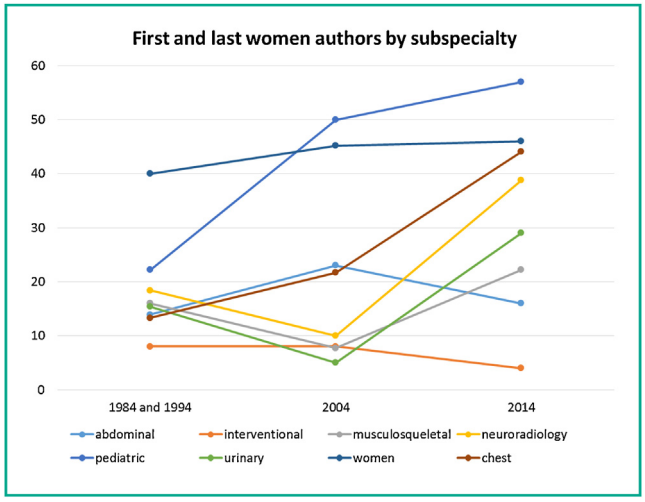

Figure 2. First and last women authorship by subspecialty from 1984 to 2014 in Diagnostic and Interventional Imaging.

mostly in pediatric (from 13.3% to 44.1%, $P = 0.03$), chest imaging (from 22.2 to 57%; $P = 0.02$) and in neuroradiology (from 18.4% to 38.8%; $P = 0.02$).

There was also a statistically significant association between first author gender and last author gender ($P < 0.001$) (Table 3). We have observed that 45% of women last authors published with women first authors, while only 21% of men last authors published with women as first authors. Accordingly, 27% of women first authors published with women last authors while only 10% of men first authors published with women as last authors.

Table 3 Cross table of last author gender by first author gender in Diagnostic and Interventional Imaging.

First author		Senior author		
		Female	Male	Total
Female	Number	40	110	150
	Percentage	6.5%	17.9%	24.4%
Male	Number	48	417	465
	Percentage	7.8%	67.8%	75.6%
Total	Number	88	527	615
	Percentage	14.3%	85.7%	100%

A significant association was found between first and last author gender ($P < 0.001$).

Discussion

There is a constant increase in women authorship in radiology for both first and last authors in the journal Diagnostic and Interventional Imaging. This increase is similar to those that have been observed in previous publications for American radiology journals [12,13].

While the percentage of women first authors is close to the one of women practicing radiology, the one of women last authors is still underrepresented. This trend is also reported in other medical and radiology journals [9,10]. The proportion of women authorship in radiology is nevertheless lower than in surgical specialties like orthopedic surgery or urology (8—17%) [14,15], while it is higher than in medical specialties such as dermatology or family medicine (46—48%) [16,17]. These differences can be explained by variation of the number of women in these specialties [14—17].

Since there has been an increase in the number of women in radiology residency over the past years [4], we can assume that the authorship contribution of women will increase as well. However, the female last authorship does not completely follow this trend, with an under-representation of women as last authors. Usually while first authors often correspond to residents and fellows in France, last authors are usually senior radiologists engaged in an academic career. It has been previously suggested that this can be related to the time gap that is needed for a young radiologist to become a leader in academic research [12]. Moreover it can be related to the persistent under-representation of women in academic careers, that might be caused by remaining social barriers as well as by low self-expectation, defined as a ''glass ceiling'' effect [18].

We have also observed, like in the study about American radiology journals [12], that female last authors are more likely to publish with female first author than their male colleagues. This tendency in female mentorship suggests the importance of female academic researchers in stimulating their junior female colleagues in engaging in research [13].

Finally, there was a discrepancy between women first and last author proportions between different radiology subspecialties. Women's imaging (breast and gynecology) had the strongest women authors' proportions over years, while pediatric and chest imaging and neuroradiology presented the strongest increase. Breast and pediatric imaging's high female authorship seems to be a worldwide tendency, continuously increasing in France [19—21], and also reported in American radiology journals [12]. This can be related to the discrepancy in representation of women in different subspecialties.

There are several limitations in our study. First, since the analysis was limited to the main French radiology journal, Diagnostic and Interventional Imaging, however French authors also publish in other French and international medical journals. Second, gender could not be established for a small proportion of authors.

In summary, women authorship in Diagnostic and Interventional Imaging has increased over the last years together with the proportion of women first authors. However, the fraction of women last authors is still underrepresented. As female last authorship reflects female mentorship and is critical to increase involvement of women in radiological research, we hope that in the coming years more women will become leaders in radiological research to contribute to stimulate women authorship.

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Disclosure of interest

The authors declare that they have no competing interest.

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