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EDITORIAL COMMENT

Sex Differences in Science

Do We Have a Problem?*

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It is no secret that women have long been underrepresented in science. Although there is no clear biological explanation, this gap might have arisen through stereotypic perceptions that women are unsuited for science, either because of imagined intellectual incapacity, fear for their fecundity, or both. Similar beliefs, as well as widespread cultural, social, and economic factors, have limited the educational opportunities available to women, further discouraging their participation in scientific research. Although there are ample data to refute such premodern stereotypes, an unequal balance between male and female scientists remains. Despite the steadily increasing numbers of women entering science, the United Nations Educational, Scientific and Cultural Organization's Women in Science data show that <30% of the world's researchers at any level are women (1). Although men and women hold roughly the same numbers of bachelor's and master's degrees, at higher academic ranks, the balance tips in favor of male scientists. In the European Union, only 20% of full professors (and still fewer natural sciences professors) are women (2). Of all tenured, full professors in the United States, only 21% are women (3). In addition to being outnumbered, women are also under-rewarded. Women are still paid less for their science-related work (4), and their contracts are more precarious. But is this sex imbalance merely a problem of basic fairness, or does science itself pay a price for the lack of female voices? A study in this issue of *JACC: Basic to Translational Science* attempts to address this question.

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In this study, Labinaz et al. (5) examined temporal trends in female authorship and mentorship and asked whether women or men are more likely to include animals of both sexes in research studies, a standard metric for experimental rigor. The investigators reviewed 3,396 articles published between 2006 and 2016 and classified them by sex of the first and last authors and by use of female animals in experiments. A mentorship relationship was assumed to exist between the first and last authors. Their analysis revealed that between 2006 and 2016, female authorship increased in both first and last positions between 2006 and 2016. They also identified a disproportionately high number of same-sex mentorships, the predominance of which persisted over time. Finally, although men and women were equally likely to report the sex of the animals used, studies led by female first and senior authors were more likely to include female animals in their experiments. This result suggests that women are more inclined to consider sex as a biological variable in preclinical experiments. At the same time, no association was found between the sex of the researcher and other measures of scientific rigor. The observed better sex-awareness in women could point to other unmeasured issues that are differentially noticed by men and women scientists. In this way, at least, underrepresentation of women in science may have ramifications not only for workforce diversity but also for critical aspects of the scientific enterprise.

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Several potential confounding factors should be considered when analyzing these data. First, the investigators selected articles from a subset of cardiovascular journals that might not be fully representative of preclinical cardiovascular journals. In addition, adjudication criteria might have been biased because author sex was determined by using an arbitrary certainty factor assigned to the first name, potentially inducing a misclassification. This was even more problematic when considering that in American English, girls' first names became less sex-obvious for the trainee cohorts publishing during the decade under study. For example, Ashley, a classic male name, rose from the 140th to the third most common girl's name between 1970 and 1980. Thus, this paper should be viewed as hypothesis-generating rather than evidence of a systematic bias.

At the same time, the paper provides potentially several pieces of good news. Women were more likely to include both sexes in their preclinical studies, but equally likely to perform randomization of animals, blinding, and sample size and/or power estimations. At the very least, this result confirmed (if confirmation was needed) that there was no cost to scientific rigor for being more inclusive. That women in both first and senior authorships increased overall during the 10 years analyzed is more good news, suggesting that a lack of female mentors may be correcting itself as more women move into cardiovascular sciences. Increased awareness and future efforts to generate equal opportunities and rewards should continue to improve sex imbalances in science.

Another finding of the study was a preponderance of same-sex mentorships that remained constant throughout the 10-year study period. It was possible that the greater representation of men in both mentor and mentee populations simply makes male-sex pairings more likely. In contrast, if there truly is a preference for same-sex scientific pairings, does this reveal a problem of bias? If so, is there a remedy? It would be useful to know whether women were just as likely as men to choose a female mentor, and whether men were training young women and men in proportion to their representation in the trainee population. If male scientists prefer to work with other male scientists, further increasing the pool of female mentors will be critical to providing opportunities for women entering the field.

So, yes, there still is an imbalance between men and women in science, both in numbers and rewards. Although specific strategies are in place to promote women and girls in health and science, much more needs to be done to bring about the widespread social changes needed to ensure sex equality in science. Alleviating this imbalance would not only be the right and fair thing to do but would have objective advantages that have been shown elsewhere: sex diverse workplaces have increased productivity and innovation, and have better employee retention and satisfaction (6). The interesting new insight by Labinaz et al. (5) is that greater inclusiveness may improve the quality and depth of science, because men and women may contribute different beneficial skills and mindsets. A more diverse research team might develop more well-argued and relevant questions, resulting in research that is applicable (and beneficial) to a broader population. Increasing efforts to further reduce the sex gap in research will likely be highly cost effective on multiple fronts.

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