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Original Research

IJES Self-Study on Participants' Sex in Exercise Science: Sex-Data Gap and Corresponding Author Survey

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ABSTRACT

International Journal of Exercise Science 16(6): 364-376, 2023. A sex-data gap exists between females and males within the sport and exercise science literature, and implications are far-reaching. The purpose of this work was to (a) heed recent calls and scrutinize data from within IJES to address the gap and (b) gain insight on self-identified sex of IJES corresponding authors. The present self-study included all published manuscripts from 2008 through 2021. A total of 851 publications were included, and 806 (94.7%) reported data on participant sex. There was a difference between publications that included only females (n = 132) versus only males (n = 215), and three publications reported data on sex according to non-binary identifications (0.4%). There was an overall difference between the number of female (n = 54,153; 35.9%) and male (n = 96,890; 64.1%) participants. To gain insight on self-identified sex of corresponding authors, we performed an IRB-approved research study. Among 761 unique corresponding authors, 168 individuals provided 157 usable responses—58 biological females (36.9%) and 99 biological males (63.1%). We fully support the prerogative of researchers to ethically conduct investigations and encourage open-mindedness and inclusion in future research. With data revealing an approximate one-third female (36%) and two-thirds male (64%) composition, and corresponding author feedback on self-identified sex being similar (36.9% and 63.1%, respectively), we propose a new concept that should be analyzed: is the sex-data gap representative of the composition of the field? We are not excusing the sex-data gap issue as if it cannot be addressed, and we urge others to join us in researching this line of inquiry.

KEY WORDS: Biological sex, gender bias, research ethics, data equity, ethics, internal evaluation, representation

INTRODUCTION

Some years ago, researchers highlighted the sex-data gap between females and males within the sport and exercise science literature. Costello and colleagues initially identified the issue by examining research publications across a three-year period within three reputable and leading sport and exercise science journals (*American Journal of Sports Medicine*, *British Journal of Sports Medicine*, and *Medicine & Science in Sports & Exercise*) (14). Of the over six million participants sampled, 2.4 million (39.0%) were females and 3.7 million (61.0%) were males. Costello concluded by calling for cognizance of sex and sexual dimorphism (14).

More recently, Cowley et al. updated and expanded upon the findings by including publications from six leading journals (the three previously mentioned, *European Journal of Sports Science*, *The Journal of Physiology*, and *Journal of Sport Science and Medicine*) over a six-year period (2014–2020) (15). The recent work affirmed the prevailing theme that the vast majority of published research includes individuals of both sexes (63%), but that male-only studies (31%) appeared significantly overrepresented compared with female-only studies (6%). Among the 12.5 million participants, 4.25 million were females (34.0%), and 8.25 million were males (66.0%, $p < .0001$) (15).

These large-scale investigations affirm the existence of a sex-data gap that appears to have remained consistent over the last eight years (14, 15). The potential implication and practical loss of application resulting from this continuing sex-data gap are far-reaching. First, it is important to note that the current authors and many others have published research providing evidence of anatomical, physiological, and psychological differences between females and males participating in athletic events. These differences are well-established in the literature and generally include females having higher percent body fat (42) and lower relative muscle mass (39), stroke volume, cardiac output, maximal aerobic capacity (26), and hemoglobin mass (18) than males. We have further found females to have slower trail-running velocity profiles (33), higher fall rates (11), and increased reporting of depression, anxiety, and stress in the early stages of the COVID-19 pandemic (22). Second, females experience sport and exercise performance, training, injury, and recovery differently than males (3, 16). However, practices of conducting male-centric research remain widespread, creating an inequity for female athletes who are unable to revise their approach to sport and exercise because of a lack of appropriate data (15). Third, females are more physiologically variable than men due to their reproductive hormones fluctuating regularly throughout the menstrual cycle and longitudinally across the lifespan (29). The impact of sex hormones (endogenous and exogenous) on physiological responses has also recently been highlighted (5). Without better representation of females in sport and exercise science research, the effect of these noted differences may not be fully realized. There is a clear need to conduct research and report findings on females in a comparable manner to male counterparts.

Despite recent research emphasizing its existence, the sex-data gap in the discipline has endured (14, 15). Self-governed remediation of this issue at the individual investigator level has not yet resolved this outcome. Nevertheless, the level of the researcher is exactly where positive and widespread change can and needs to occur. Being student-focused, the *International Journal of Exercise Science* (IJES) is uniquely positioned to influence undergraduate and graduate students, emerging scholars and clinicians, and academic advisors with respect to this critical issue. Further, IJES is distinctively connected with regional and national audiences through its publication of conference proceedings for recognized organizations. The focus and reach of IJES afford it the rare opportunity to raise awareness about and begin addressing the sex-data gap in the sport and exercise science literature. The purpose of this work was to (a) heed recent calls (14, 15) and scrutinize data from within our journal to address the issue in a unique way and (b) gain insight on self-identified sex of corresponding authors as it relates to sex assignment on their birth certificate and current gender identity.

THE INTERNATIONAL JOURNAL OF EXERCISE SCIENCE SELF-STUDY

IJES first began publishing articles in 2008 (8). This present self-study included all published manuscripts from the first volume and issue (1:1) through the latest complete year at the time of writing (2021, volume and issue 14:7) (31). The data extraction methods described by Cowley et al. were followed (15). Briefly, abstracts and full texts were individually screened to determine the opportunity for data extraction. Original research and technical notes were included, while invited editorials, position stands, reviews, data-evaluation studies, and studies using animal models were excluded. Publications had to specify a sample size and the number of participants by sex for inclusion.

The self-study was delimited to a binary definition of sex. Admittedly, by including only two sexes (female and male), we failed to capture an important portion of the population—those who do not identify according to binary sex. We are using binary language as was specified in the original publications, and we acknowledge divergence from binary sex designations in the publications that identify such details.

The total number of participants and the total number of females and males were recorded for each manuscript meeting the inclusion criteria. The titles were also screened, and information recorded if (a) the title identified what sex was included in the study and (b) the publication focused on a sex-specific topic (e.g., specific hormone concentration). Chi-squared analyses (X^2) were used to compare both the expected number of publications and the expected number of participants that included females and males (Microsoft Excel 2022 version 16.58, Redmond, WA). Effect size (φ) interpretation was <0.1 = trivial, 0.1-0.29 = small, 0.3-0.49 = medium, >0.5 = large (13). Significance was accepted at the $p < 0.05$ level.

Findings: A total of 851 publications were identified for the analysis (see Figure 1). Of these publications, 806 reported data on participant sex (94.7%). Of the publications that reported data on participant sex, 459 (56.9%) included data on both sexes. There was a difference between the number of publications that included only females (132; 16.4%) and only males (215; 26.7%), and the bias toward male-only publications was significant, X^2 (1, n = 459) = 42.5, p < 0.001, φ = 0.304.

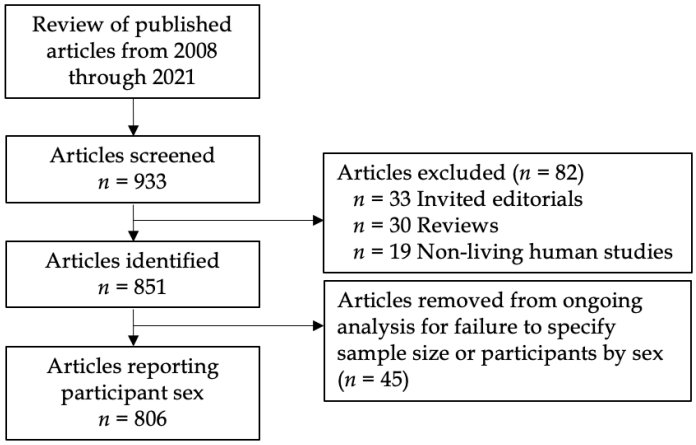

Figure 1. Flow diagram of the number of manuscripts from 2008 through 2021 in the *International Journal of Exercise Science* (IJES) that were identified, excluded, included, and analyzed in the IJES Self-Study.

A total of three publications (of 806) reported data on sex according to non-binary identifications (0.4%). Extracted data revealed one participant identified as transgender (7), three participants put 'Other' as their preference (7, 30, 32), and one participant did not identify their gender (7).

The total of 806 publications included data on 151,043 participants classified in a binary fashion. There was an overall bias toward male participants, X^2 (1, n = 151,043) = 12,092.3, p < 0.001, φ = 0.283 and there was a significant overall difference between the number of female (54,153; 35.9%) and male (96,890; 64.1%) participants. As depicted in Figure 2, there was a significantly greater number of male than female participants for nine years of the publishing span investigated (2008, 2011, 2013–2015, 2017–2020; all X^2, p < 0.001). Conversely, there was a significantly greater number of female than male participants for three years (2010, 2016, 2021; all X^2, p < 0.001). There was no difference between the number of female and male participants for two years (2009: X^2 (1, n = 1,497) = 0.193, p = 0.660, φ = 0.01 and 2012: X^2 (1, n = 2,367) = 0.186, p = 0.666, φ = 0.01).

Notably, there were several large-scale studies published in the journal in 2014, 2019, and 2020. In 2014, Eldridge and colleagues published the largest study to date with 35,030 participants (16,673 females and 18,357 males; 47.6% and 52.4%, respectively) (19). In 2019, Gillen and colleagues included 7,214 males in an all-male study (23), and Kamara and colleagues published a study with 5,945 participants (2,346 females and 3,599 males;

39.5% and 60.5%, respectively) (27). The combination of two large studies accounts for the surge of participants seen in 2020. Ferland and colleagues published a study with 26,472 participants (9,049 females and 17,423 males; 34.2% and 65.8%, respectively) (21), and the work of Keefer and DeBeliso propelled the male population that year, as they included 19,678 males in an all-male study (28).

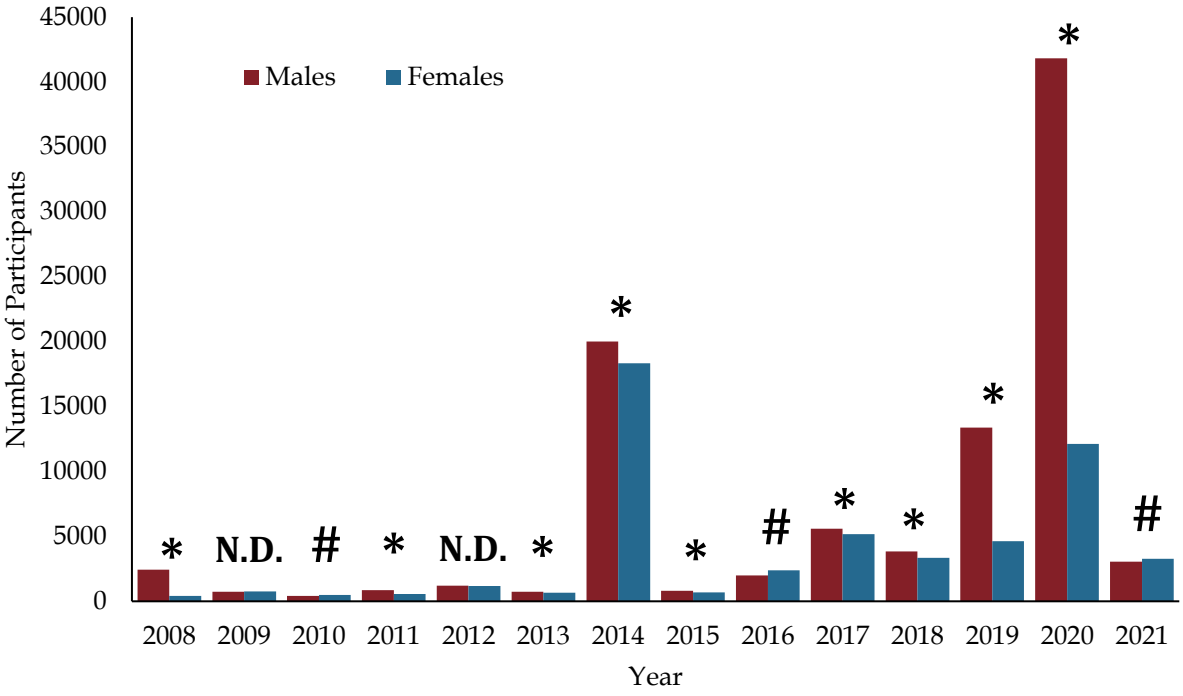

Figure 2. The absolute number of female and male participants in the *International Journal of Exercise Science* (IJES) publications by year. *indicates a significantly greater number of male participants. #indicates a significantly greater number of female participants. N.D.indicates no difference between the number of male and female participants.

From 2008 through 2021, 347 publications reported data on one sex (132 female-only, 215 male-only), and 140 publications designated participants' sex in the title. Eight of the 140 publications referred to both sexes in the title (5.7%). Among the other 132 articles, 87 referred to females in the title and 45 referred to males. More publications that included exclusively female participants (87 of 132 publications; 65.9%) stated the sex of the sample in the title compared to those including exclusively male participants (45 of 215 publications; 20.9%), X^2 (1, n = 347) = 138.3, p < 0.001, φ = 0.631. A closer examination revealed a difference between publications that focused on sex-specific topics. More publications focused on female-specific factors (e.g., hormonal changes with menopause, ovarian cancer or cysts) and included only females than focused on male-specific factors (e.g., testicular cancer, testosterone levels after prostatectomy) and included only males, X^2 (1, n = 347) = 308.7, p < 0.001, φ = 0.943. Among the 132 publications that included only females, 17 investigated female-specific factors (12.9%). On the other hand, of the 215 publications that included only males, three investigated male-specific factors (1.4%).

THE INTERNATIONAL JOURNAL OF EXERCISE SCIENCE CORRESPONDING AUTHOR SURVEY

To gain insight on self-identified sex, we performed an IRB-approved (Sam Houston State University IRB Protocol IRB-2022-112) research survey. The work was carried out in full compliance with the ethical standards of IJES (34), and the survey consisted of four questions (paraphrased below):

- Are you willing to answer a question about sex assigned on your birth certificate?
- What sex were you assigned at birth?
- What is your current gender?
- Would you be willing to provide us an article name or your official name under which you published with IJES?

All corresponding authors who published from 2008 through 2021 were identified. After removing authors with multiple IJES publications, a total of 761 unique corresponding authors (often also the primary author, but not always) were sent the four-question, self-identified-sex survey on three occasions between May and November 2022. A flowchart offering details about perceived email delivery, the response to each of the three sendings, and related information is shown in Figure 3 and described further below.

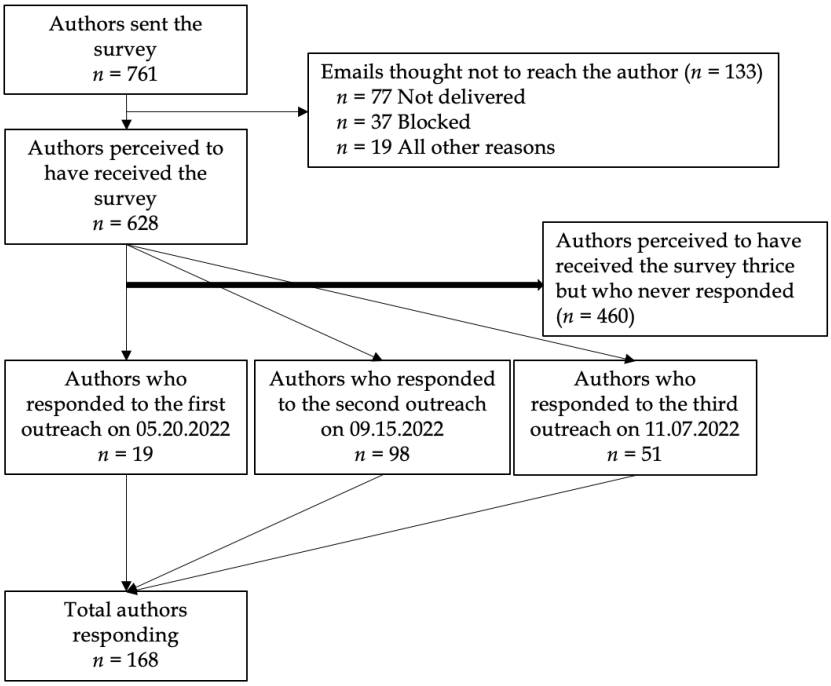

Figure 3. Flow diagram of corresponding authors on manuscripts from 2008 through 2021 in the *International Journal of Exercise Science* (IJES) who responded to an author outreach survey on biological sex and gender identity.

An accounting of email outreach revealed high numbers of undelivered or blocked emails (n = 133 of 761; 17.5%), which precluded authors from responding. The failure of 133 emails to be delivered is not surprising, considering the student-centric nature of IJES and how often students and professionals within academic and clinical settings change affiliations and thus email addresses. Further, it is likely that name changes or the acquisition of new emails leaves some email addresses obsolete, unused, or deleted. It was perceived that 628 authors received the self-identified sex survey, but the bulk did not respond to the outreach (n = 460 of 628; 73.2%).

There was an erroneous link provided in the initial May 2022 outreach to authors, which resulted in the salvaging of only nineteen sets of usable data (19 of 628; 3.0%). Accordingly, the September (n = 98 of 628; 15.6%) and November (51 of 628; 8.1%) outreaches accounted for most of the data. In total, 168 authors responded. Among the 168 authors, 108 (64.3%) willingly reported an article they published in IJES or their name to be used for secondary analysis later. Table 1 offers insight on biological sex, corresponding gender identity by biological sex, and the other responses. Analyzed further, for 157 respondents who we can track binary sex, 58 were biological females (36.9%) and 99 (63.1%) were biological males.

Table 1. Matrix of biological sex and gender identity for 168 *International Journal of Exercise Science* (IJES) corresponding authors clicking on the survey.

Sex on Birth Certificate	Gender Identity of Female	Gender Identity of Male	Gender Identity of Agender	Total of 168
Survey Entered but No Selections Made	~	~	~	8
Not Willing to Participate	~	~	~	3
Biological Female	57	0	1	58
Biological Male	0	99	0	99

PRACTICAL APPLICATIONS: THOUGHTS FOR YOUNG INVESTIGATORS AND ADVISORS

When studied alongside emerging literature, the self-study and corresponding authors' self-identified-sex survey revealed several important opportunities into which the journal can encourage and expand its positive influence. Before presenting the takeaways below, a few high-level introductions are worth noting. Expanding data collection tools to include biological sex and gender identity could augment understanding of the discipline. Use of emerging literature should enhance the abilities of researchers to include females in more studies. There is value in reporting where menstruating female participants are in the menstrual phase and conducting research on pregnancy and post-partum particularities. Finally, unless studying a sex-specific topic, it is important to design sufficiently powered investigations to represent females, males, and those who do

not identify according to binary sex—this would allow samples to be split based on sex (or gender) if there is an interaction.

The first takeaway is that data collection tools should allow participants to report sex in a binary fashion or select from additional options. It will be interesting and valuable to analyze the data that returns. In the present corresponding authors' self-identified-sex survey, all biological males reported gender identity as a man, and all but one biological female reported gender identity as a woman. However, over 73% of the corresponding authors failed to respond. We do not know if the non-responding corresponding authors would continue to follow this trend. Further, we are not able to speculate if self-identified biological sex matching gender identity (e.g., biological female identifies as a woman) influences whether a researcher offers nonbinary selection options in their research. We know that only three of 806 publications reported data on sex according to non-binary identifications, but we cannot know if the other 803 studies offered options beyond binary sex. We conclude that researchers should use tools that allow participants to self-identify sex designation.

Second, sex-specific factors do not appear to be the singular reason that only one sex is included in a study. Recall the results above noted that only 17 of 132 (12.9%) publications that included only females studied a female-specific factor, and only 3 of 215 (1.4%) publications that included only males studied a male-specific factor. We ask ourselves and others, do authors feel less need to mention the word male in the title of male-only studies compared with mentioning the word female in the title of female-only studies? Is there a greater, or different, benefit to mentioning female in the title of female-only studies? We suggest others might research reasons behind this finding.

We fully support the prerogative of researchers to ethically investigate whomever or whatever they desire, but we also encourage open-mindedness and call for more sport and exercise science researchers to include more female participants, relinquishing the dogmatic belief that females should be excluded because the menstrual cycle may confound the research. Recent literature provides insight on research design around sex differences, oral contraceptives, and the menstrual cycle to help aid in the design process (25, 38). Sims and Heather give observations into hormonal profiles (endogenous and exogenous) across standard-length menstrual cycles (38), while Janse de Jonge and colleagues provide insight into verification of menstrual phase via calendar-based counting and hormonal testing of urinary luteinizing hormone and serum estrogen and progesterone (25). These and many other publications are represented in the proliferating literature surrounding sex-cognizant topics, and readers are referred to an excellent review by O'Bryan that distinctly addresses the issue in exercise biology and medical arenas (35).

Third, researchers might fruitfully consider methods to study topics about sport and exercise during and after pregnancy. Pregnancy is commonly defined by rest, low-

intensity movement, and decreasing movement as gestation progresses, but we know there are many benefits to exercise during pregnancy (17, 41). There should be heightened promotion of exercise recommendations that are safe and efficacious to the fetus and mother in the prenatal period, gestational period, and in preparation for postpartum (12, 24, 37). The American College of Obstetricians & Gynecologists supports physical activity during pregnancy as well as the postpartum period (1, 2), and a 2023 call to action for promoting "exercise is medicine in pregnancy" was made (37). Raising awareness of what factors impact return to exercise (e.g., body weight changes, social support) and training maternal healthcare workers in exercise prescription would paint a more complete picture of the adoption, maintenance, and outcomes of exercise around pregnancy (12, 24, 37).

Fourth, unless studying a sex-specific topic, it is important to design and sufficiently power investigations to equitably represent females, males, and those who do not identify according to binary sex. We acknowledge that some testing methodologies, disease states, sex-specific topics, or settings naturally influence inclusion or exclusion criteria or offer unequal distributions that skew sampling toward a biological sex. The following examples represent this concept but are certainly not exhaustive. First, there could be justified inclusion or exclusion of biological females if dual-energy x-ray absorptiometry were being employed. Scan frequency, pregnancy potential, menopausal status, or governing law might be reasons for the choice (10). Second, enrollment of those with certain diseases could influence samples. With diseases such as breast cancer (6), arthritis (9), and osteoporosis (4), the recruitment opportunities skew toward the biological female. On the other hand, studying Parkinson's disease (36) or gout (43) will likely yield a majority of biological males in the recruitment pool. Third, it is reasonable that studying ovarian cancer or cysts would preclude the inclusion of males in the same way that investigations of testicular cancer would preclude the inclusion of females. Lastly, there are settings or occupations where unequal sex distributions might foil attempts at equal recruitment of the biological sexes. Tactical areas (e.g., males in the military) (40), specific sports (e.g., females across levels of gymnastics and males in American football), and people who are incarcerated (more males) (20) are examples. Unless studying a sex-specific topic, we promote targeted recruitment of females, males, and those who do not identify according to binary sex. Further, in situations where a predominance of a given sex would be expected, we believe there is value in researchers mentioning this in their introduction and discussion when commenting on recruitment pool and sample outcomes.

CONCLUSION AND PROMISE

This self-study within the confines of IJES reveals some interesting ideas. We embarked on an effort to scrutinize the enduring sex-data gap that was highlighted by Costello and colleagues (39% females and 61% males) (14) and Cowley and colleagues (34% females and 66% males) (15) to see if this outcome was present in articles published within IJES

from 2008 through 2021. Indeed, it was. We found an intriguing alignment between their data and ours—we uncovered an approximate 1:2 ratio of females (54,153; 35.9%) to males (96,890; 64.1%). Further, when we solicited corresponding author feedback on self-identified sex, we found the responses to remain near this same ratio (58 biological females; 36.9% and 99 biological males; 63.1%).

We surmised that the level of the researcher is where positive and widespread change can occur to increase recruitment of females within the discipline. This is certainly true, but now we are speculating on an alternate idea. We propose a new concept that should be analyzed by researchers. Did the initial (14) and follow-up (15) research across a range of respected journals and our research focused on IJES publications all find the sex-data gap to be present and enduring because the field is currently represented by roughly 34% females and 66% males? In effect, could it be improbable to expect that researchers should arrive toward equal samples of biological females and males in the typical study because the discipline is currently skewed significantly away from females? We do not know, nor are we excusing the issue as if it cannot be addressed, but we urge others to join us in continuing research in this line of inquiry.

There is much work to be done in determining what is true of the sex-data gap in the sport and exercise science literature. In light of this uncertainty, IJES desires to bring stability and continues its promise to remain a student-focused journal that publishes the high-quality work of young investigators, undergraduate and graduate students, and the scholars and clinicians with whom they collaborate. The strong connection of IJES to regional and national conferences is consummate. We have provided some suggestions above as mechanisms to improve the inclusion of biological females; the collection of data on biological sex, gender identity, the menstrual cycle, and pregnancy-based variables; and the transparent reporting of samples skewed toward a biological sex. These recommendations could prime future works for being clearer to readers and allowing greater detail to be gleaned from the outcomes. Moreover, we look forward to future submissions to the journal that promote the ideas within this present work so as to solidify the ever-improving value of our journal.

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