

# Under-representation of female athletes in research informing influential concussion consensus and position statements: an evidence review and synthesis

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## ABSTRACT

**Objective** We aimed to quantify the female athlete composition of the research data informing the most influential consensus and position statements in treating sports-related concussions.

**Design** We identified the most influential concussion consensus and position statements through citation and documented clinician use; then, we analysed the percentage of male and female athletes from each statement's cited research.

**Data sources** We searched PubMed on 26 August 2021 with no date restrictions for English language studies using the terms 'concussion position statement' and 'concussion consensus statement.'

**Eligibility criteria for selecting studies** Based on each statement having multiple statement editions, documented clinician use, and substantial citation advantages, we selected the National Athletic Trainers' Association (NATA, 2014), International Conference on Concussion in Sport (ICCS, 2017) and the American Medical Society for Sports Medicine (AMSSM, 2019). We extracted all cited studies from all three papers for assessment. For each paper analysing human data, at least two authors independently recorded female athlete participant data.

**Results** A total of 171 distinct studies with human participants were cited by these three consensus and position papers and included in the female athlete analyses (93 NATA; 13 ICCS; 65 AMSSM). All three statements documented a significant under-representation of female athletes in their cited literature, relying on samples that were overall 80.1% male (NATA: 79.9%, ICCS: 87.8%, AMSSM: 79.4%). Moreover, 40.4% of these studies include no female participants at all.

**Conclusion** Female athletes are significantly under-represented in the studies guiding clinical care for sport-related concussion for a broad array of sports and exercise medicine clinicians. We recommend intentional recruitment and funding of gender diverse participants in concussion studies, suggest authorship teams reflect diverse perspectives, and encourage consensus statements note when cited data under-represent non-male athletes.

## INTRODUCTION

Each year, between 1.6 and 3.8 million Americans suffer sports and recreation-related concussions.<sup>1</sup>

## WHAT IS ALREADY KNOWN ON THIS TOPIC?

⇒ Concussion presentation and recovery among male and female athletes have similarities, but also may differ in pathophysiology or health-related behaviours in ways that affect clinical care.

## WHAT THIS STUDY ADDS?

- ⇒ Consensus and position statements outlining concussion management are critical to guiding clinical care; however, we show the studies that inform them have vastly under-represented female athletes. The three most influential consensus and position statements with three different writing methodologies each reflected a similar bias in the literature.
- ⇒ The most influential consensus and position papers average only 19.9% female participants in the human subjects research supporting their recommendations. Moreover, 40.4% of the studies cited in the most prominent consensus and position papers include no female participants at all.
- ⇒ Under-representation of female athletes in the data underlying concussion consensus and position papers may result in protocols that are more targeted for male athlete recovery.

## HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ Future research in sport-related concussion should intentionally recruit and fund gender diverse participants, include diverse authorship teams, and acknowledge when cited data under-represent non-male athletes.

Recreational sports participation is a leading cause of concussion in the USA.<sup>2</sup> Accordingly, there has been an increased interest and available funding directed toward concussion research. Ongoing advancement through the International Conference on Concussion in Sport (ICCS)<sup>3-5</sup> and other medical organisations<sup>6-8</sup> have aimed to more effectively treat athletes through evidence based clinical care among other goals. These consensus and position statement processes form the standard of care used by clinicians treating patients with concussion.



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The effort of these iterative consensus and position statements has helped crystallise gaps in our knowledge and set a clear agenda for advancing clinical care for concussion over the years. The ICCS started this trend for concussion consensus publication at the Vienna meeting in 2001, with four more subsequent iterations—most recently Berlin in 2017<sup>3-5 9 10</sup> and has been cited 1980 times across all editions. The National Athletic Trainer's Association (NATA) followed suit with a position statement in 2004,<sup>11</sup> updated in 2014,<sup>6</sup> which have been cited 256 times. The American Medical Society for Sports Medicine (AMSSM) published its first statement in 2013<sup>7</sup> with an update in 2019,<sup>8</sup> which have been cited 281 times. Concussion-related publications have dramatically increased since the introduction of the consensus process, necessitating periodic updating of the consensus and position statements. While the concussion literature is growing, there remains continuing clinical questions about how concussions may differ between male, female, transgender and non-binary athletes.<sup>12</sup> Anecdotally, gender-based clinical considerations of concussion are common, but to date no publication has quantified the gender composition of the clinical concussion literature in these consensus and position statements—or of the concussion literature more broadly. If female athletes are under-represented within the sports-related concussion (SRC) literature—particularly in key documents that inform clinical practices—clinicians would face considerable challenges in effectively treating female concussion patients.

Under-representation of female athletes in concussion research has practical consequences for their healthcare and the trajectory of concussion research. Concussion recovery differences in female athletes may be driven by sex (the biological differences between male and female) or by gender (the socially constructed roles of men and women).<sup>13</sup> Within medical research, this distinction has only more recently gained broader traction,<sup>14</sup> but considerable evidence shows that female athletes have different responses than male athletes to concussions on both the physiological and the psychosocial level.<sup>15</sup> Women are more likely to receive a concussion than male athletes playing the same sport (eg, male vs female soccer, ice hockey or rugby),<sup>15-17</sup> possibly resulting from lower cervical strength,<sup>18-20</sup> different hormone levels,<sup>21 22</sup> and/or social factors.<sup>23</sup> Lower cervical strength relative to head mass among female athletes suggests differing head impact biomechanics may influence concussion.<sup>24</sup> Hormone levels may even create concussion-specific vulnerability windows,<sup>25</sup> while also complicating the clinical assessment<sup>26</sup> and implicating biological sex as a factor in concussion vulnerability. Within the sociocultural realm, female athletes have generally shown greater willingness to report concussions or symptoms<sup>27-29</sup> that could impact nearly every self-report measure in concussion and implicates gender-driven acculturation as a factor in recovery. These factors may also individually or collectively influence injury recovery. Following concussion, female athletes show different—potentially longer—recovery trajectories when compared with men, with women taking roughly 10 more days to recover in some studies,<sup>30-34</sup> but others failing to find overall recovery differences at all.<sup>35</sup> Finally, female athletes have been shown to suffer abnormal menstrual cycles<sup>22</sup> and sexual dysfunction<sup>36</sup> after concussions, highlighting just two potential long-term health effects for women that have been identified with a completely different presentation.<sup>36</sup> In a male athlete population. In short, the combination of sex-based and gender-based differences in concussion are so pervasive that having an equitable representation of female athlete-focused studies would be essential for informing clinical practices in a way that ensures equitable treatment.

While this female athlete disparity in concussion research is often recognised,<sup>12 37</sup> it is difficult to quantify because of the breadth of the concussion literature and the rate at which this literature is growing. In order to ascertain the representation of female athlete data, our research team focused on analysing the female athlete composition of the three most cited consensus or position statements from three different organisations based on their influential roles within the SRC research and clinical care landscape: the NATA (2014),<sup>6</sup> International Consensus Conference on Concussion in Sport (ICCCS) who met in 2016—sometimes called the Concussion in Sport Group (CISG),<sup>3</sup> and the AMSSM (2019).<sup>8</sup> Each of these statements was assembled by a team of international experts and focused solely on the research that met the published inclusion criteria. While each organisation stated slightly different aims, our goal was to repurpose the output of these panels to examine the cited literature for male versus female participant balance. We are unaware of any publication that quantifies the gender imbalance in concussion research.

Our expectation was that historical bias towards male athletes would shape concussion research literature to under-represent female athletes. We specifically hypothesised that (1) a greater proportion of studies would focus predominantly on male participants and (2) the overall proportion of participants comprising the concussion sample population—across many studies—would be predominantly male.

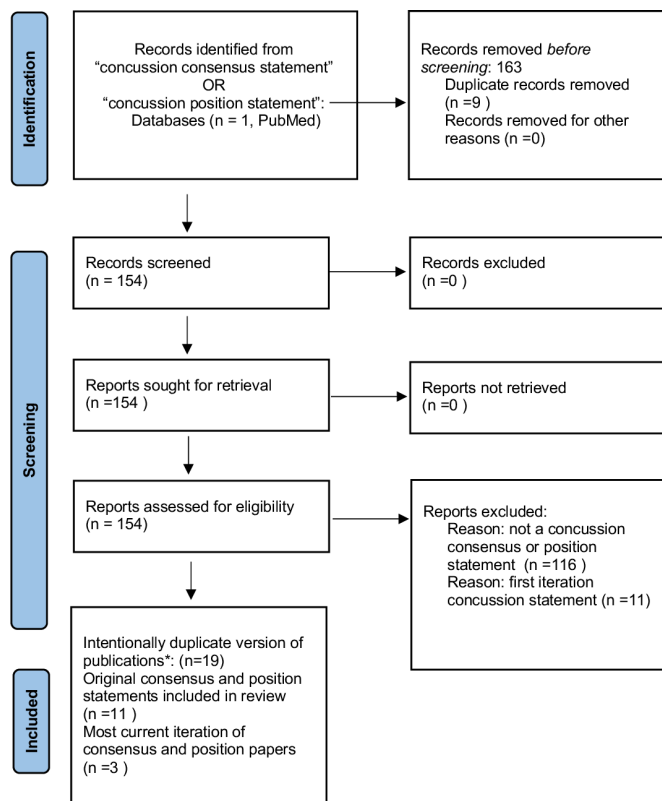
## METHODS

### Selection of consensus statements

The NATA, ICCS and AMSSM organisations' papers were originally selected as the most influential consensus and position statements within SRC based on historical trends and clinician use.<sup>38 39</sup> Studies of clinician behaviour have shown that sports medicine staff tend to rely on their organisational position and consensus statement plus the most recent ICCCS paper in tandem to stay current on treating concussions. For example, certified athletic trainers (ATs) rely on the Berlin statement and the NATA statement<sup>38</sup> for concussion knowledge, while sports medicine physicians use the most recent AMSSM statement and ICCS statement.<sup>39</sup> Further, no other concussion statements have been published with multiple versions by any other organisation (see figure 1).

We aimed to ensure that we did not fail to include any similarly influential SRC consensus and position papers. To do this, we used PubMed to identify the most commonly cited consensus and position statements on concussion, searching 'concussion consensus statement' and 'concussion position statement' to determine viable consensus statements (see figure 1, selection diagram). Searches were restricted to English language publications with no date restrictions. For each assessed consensus paper or position statement, we summed citations across all versions to determine cumulative influence. The NATA, ICCS and AMSSM organisations' papers were confirmed as the most cited consensus and position statements within these search results with greater than 200 citations each. No other organisation's consensus or position statements had published multiple editions or a similar citation count. In short, citation patterns, publication of multiple versions and research on clinician behaviour all indicate that these are the most influential SRC statements.

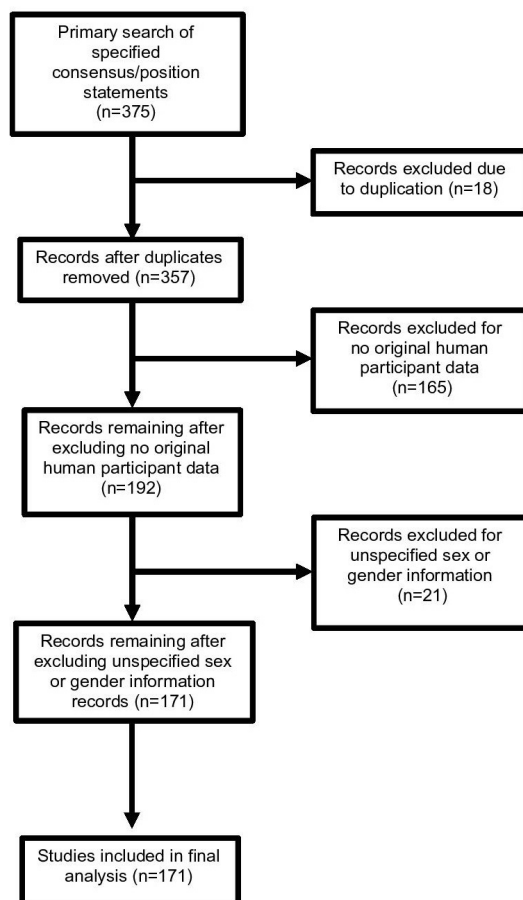
We restricted our analysis to these three statements. The US Air Force Academy IRB designated this study as not human subjects research.



**Figure 1** Selection diagram for identifying the influential concussion consensus and position papers. Consensus papers often have intentional copublication to maximise outreach to different communities—for example, to ensure that both neurologists and certified Athletic Trainers are aware of updated concussion guidelines. We summed citations to identical co-publications of consensus statements, but only analysed the most recent iteration of each statement.

### Statistical methods for quantifying male and female athlete data

For each statement, we aimed to capture the male and female athlete data comprising the research cited. Any reference that did not analyse human participant data was classified as non-human research (different from the IRB designation) and excluded from statistical analyses—including any review papers. For each study that recorded or implied gender information, we tallied the total number of male and female participants and computed the proportion of male athletes. Due to the wide temporal window of these studies, gender and biological sex were often conflated in older methods sections; our analyses recorded these values as the original investigators reported them. Research occasionally reported participants in all-male leagues (eg, National Football League, NFL) without any gender or sex information; we classified these study's participants as all male. Otherwise, when studies did not clearly state proportions for sex or gender, they were removed from analysis. To classify the sex/gendered composition of each study, we used two primary outcomes measures. First, we categorised the gender distributions reported by each cited study as either all male or all female, then we split the remaining studies with mixed participants into thirds: mostly male (99%–67% male), roughly equal (34%–66% male) or mostly female (67%–99% female). We also used descriptive statistics to show the number of studies that fell in each category both combined and individual by statement. We used Kolmogorov-Smirnov tests, and corresponding skewness values,



**Figure 2** CONSORT flow chart for inclusion and exclusion of studies extracted from the three position and consensus papers. CONSORT, Consolidated Standards of Reporting Trials.

to determine whether continuous outcomes of percentage of male participants were normally distributed both combined and individually by statement. We considered values  $<-1$  or  $>1$  to be highly skewed, values between  $-1$  and  $-0.5$  or between  $0.5$  and  $1$  as moderately skewed, and values  $>-0.5$  or  $<0.5$  to be approximately symmetrical.<sup>40</sup> Negative values indicated a skew towards male participants. We have included this spreadsheet as a supplement and will make this spreadsheet freely available on publication (see [figure 2](#) for details).

### RESULTS

Identification and descriptive information about consensus and position statements.

As each society has published multiple statement versions, we only analysed the most recent iterations here. Each method for producing the selected consensus and positions statements are described below.

#### National Athletic Trainers Association (2014)

The NATA statement's stated objective is to 'provide ATs, physicians and other healthcare professionals with best-practice guidelines for management of SRCs.' It has been cited 256 times across both editions. The statement notes that ATs are typically the first line of treatment for SRCs in the USA. This statement used SORT to rank the evidence for each study under review.<sup>41</sup> This statement cites 201 references.

### International Conference on Concussion in Sport (2017)

The ICCS has evolved since its first consensus agreement into a standardised research integration process of considerable public health importance and has published a description of <sup>42</sup> 'AT the agenda for future research relevant to SRC by identifying knowledge gaps.' Its most recent statement was published in 2017 following the 2016 meeting in Berlin.<sup>3</sup> It has been cited 1980 times across all editions. It is sometimes referred to collectively as the CISG. For the Berlin meeting, a core scientific panel was convened alongside an expert panel of international experts. This premeeting process narrowed 45 possible questions to be answered by the Consensus meeting down to 12 questions through a modified Delphi process. As described in the methods publication,<sup>42</sup> the ICCS then designated lead authors to organise the systematic reviews in each sub-field matched to each author's expertise. Authors searched nearly 60 000 articles, selecting the best for review using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses and Enhancing the QUALity and Transparency Of health Research guidelines.<sup>43</sup> These systematic reviews were then presented at the public meeting for expert comments and used to inform the consensus statement. This statement cites 46 references.

### American Medical Society for Sports Medicine (2019)

The AMSSM review is stated 'to provide a narrative review of the existing literature and best practices to assist healthcare providers with the evaluation and management of SRC, and to establish the level of evidence, current knowledge gaps and areas requiring additional research.' It has been cited 281 times across both editions. The Board of Directors for this group nominated the chair and lead author, who then chose the writing group to represent diverse knowledge sets, including sideline and office-based care. This group of 13 authors collaborated across several conference calls and group communications before meeting in 2018 to collaboratively write the statement. Studies were judged by the SORT strength of evidence mechanism.<sup>41</sup> This statement cites 128 references.

### Analysis of athlete data

Across all three consensus and position statements, a total of 375 cited publications were reviewed. Our initial screening removed citations with (1) no human participants (2) no indication of gender or sex if there were human participants and (3) duplicate references. This filtering step removed 204 citations, leaving 171 for combined analyses of female and male athlete data (figure 2 and online supplemental figure 1). Duplicate citations were included for individual analyses of each position statement, but included only once when all three documents were evaluated together. Individual analyses included 93 from the NATA, 17 from the ICCS and 68 from the AMSSM. Eighteen (18) papers were cited in two of the consensus documents, while none were cited in all three.

Studies cited by the three consensus/position statements analysed relied on samples that were overall 80.1% male (NATA: 79.9%, AMSSM: 79.4%, ICCS: 87.8 %). These were all significantly skewed towards male participants both overall ( $p < 0.001$ ) and for each individual statement ( $p < 0.001$  for all), with moderate skewness of  $-0.911$  overall (NATA:  $-0.866$ , moderately skewed; AMSSM:  $-0.950$ , moderately skewed; ICCS:  $-1.257$ , highly skewed). Of the 171 studies analysed across the three statements, 69 (40.3%) had all-male samples, but only two (2, 1.2%) had all-female samples (figures 3 and 4).

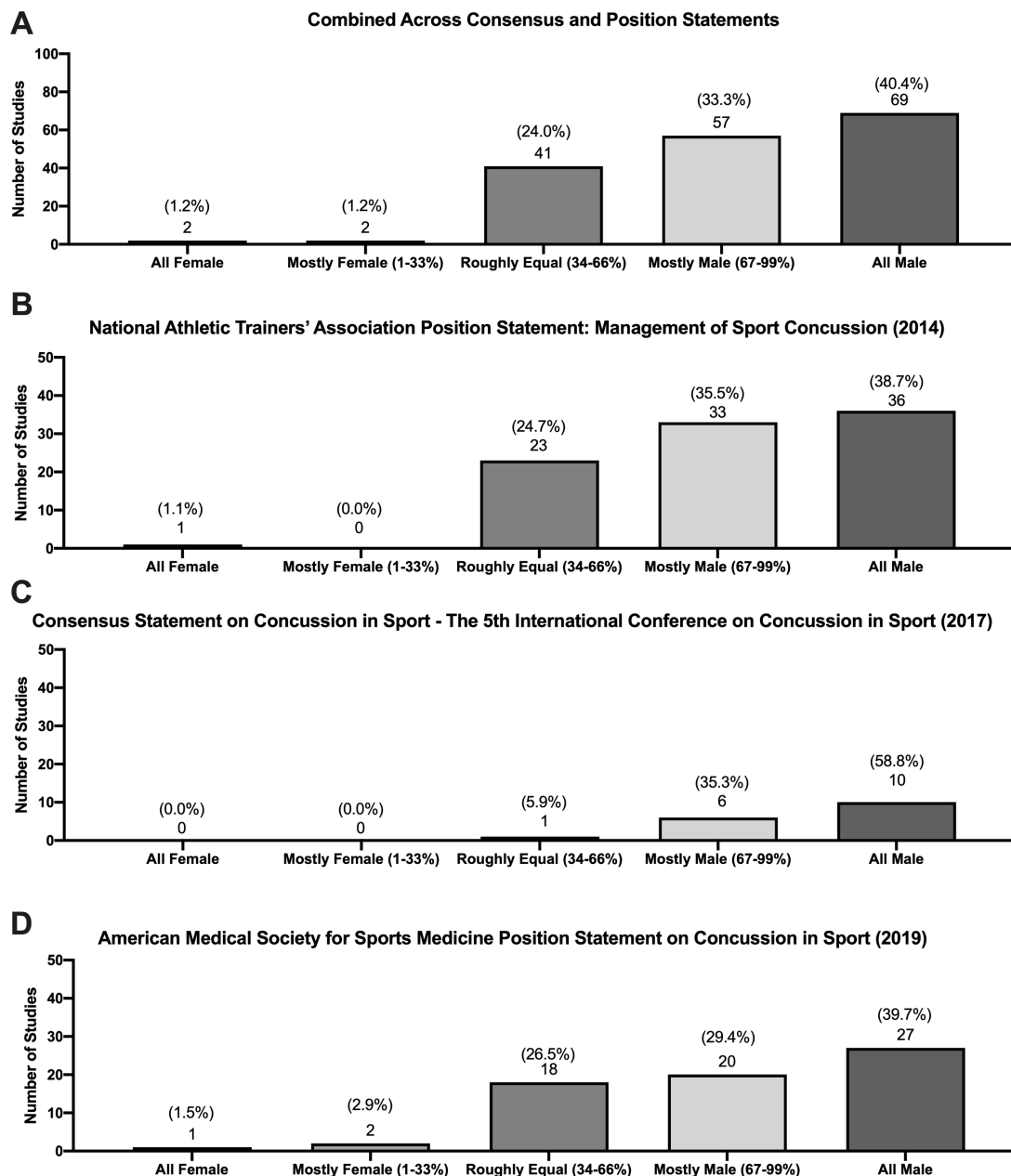
### DISCUSSION

We found that female athletes are significantly under-represented in the highest impact concussion documents that outline clinical care, as represented by three expert-curated position and consensus statements on concussion from the NATA, ICCS and AMSSM. Clinicians rely on these documents to guide their medical practice, but they may be based on scientific evidence that is not sufficiently representative of female athletes. This disparity may lead to inequitable treatment of female athletes who suffer concussions.

Our results show a profound under-representation of female participants in the concussion consensus literature, matching the imbalances others have documented in the broader sport and exercise medicine literature.<sup>44</sup> Samples within studies published in three prominent sport and exercise medicine journals we analysed were just 19.9% female. Each statement mentioned female athletes only briefly, typically when describing sex as a modifying factor for return-to-play time.<sup>3 6 8</sup> It may be expected to have some imbalance in gender representation in concussion research, but the drastic differences are likely due to multiple nested factors. First, current concussion research originated from the 'sport as a laboratory' model, whereby researchers use sport as a controlled environment to conduct studies. With the scarcity of research dollars and resources in early concussion funding, researchers had to use their resources in environments where concussion incidence is high and rosters are large. For example, a football roster with 105 participants could be expected to produce 5.63 concussions per season, while a women's volleyball team with a standard roster of 12 would produce only 0.46, meaning researchers would need to follow roughly 12 women's teams for the same amount of data as one football team despite similar roughly risk. With football being the largest single source of concussions, early sport concussion research in the late 1990s began with college and professional football<sup>45-49</sup> before expanding to other sports.<sup>50</sup> Large roster, high incidence sports—primarily collision sports—are therefore the most efficient study model.

Historically, women's opportunity to play sports was limited in the US until Title IX was enacted, and once in place athletics programmes gradually increased participation to equal numbers.<sup>51</sup> Even so, contact/collision sports continue to be largely male-oriented, potentially reducing the perceived need for female-based research. The historical trend in inequity has similarly reduced opportunity for female-focused retrospective research. Several large studies of postconcussion mental health in retired NFL, NCAA and other male professional athletes<sup>46 52-55</sup> have no parallel female cohort. As one example, Mayo Clinic researchers were able to assess hundreds of former high school football players for neurological testing after identifying them through decades of Rochester, Minnesota high school yearbooks<sup>56</sup> while simultaneously noting, 'female sports programmes were not consistently offered' during this time.

Similarly, disproportionate male participation in, and support for, athletics ensures that many sponsor organisations supporting concussion research are male-dominated or all male—such as International Federation of Association Football, the International Ice Hockey Federation and the NFL. The NCAA-US Department of Defense Grand Alliance is one of the few relatively gender-balanced efforts to support clinical concussion research by funding the CARE Consortium.<sup>57 58</sup> Recent efforts by the CARE Consortium make significant strides towards correcting this imbalance<sup>58</sup> with females representing roughly 50% of the NCAA athlete sample. Epidemiological databanks,



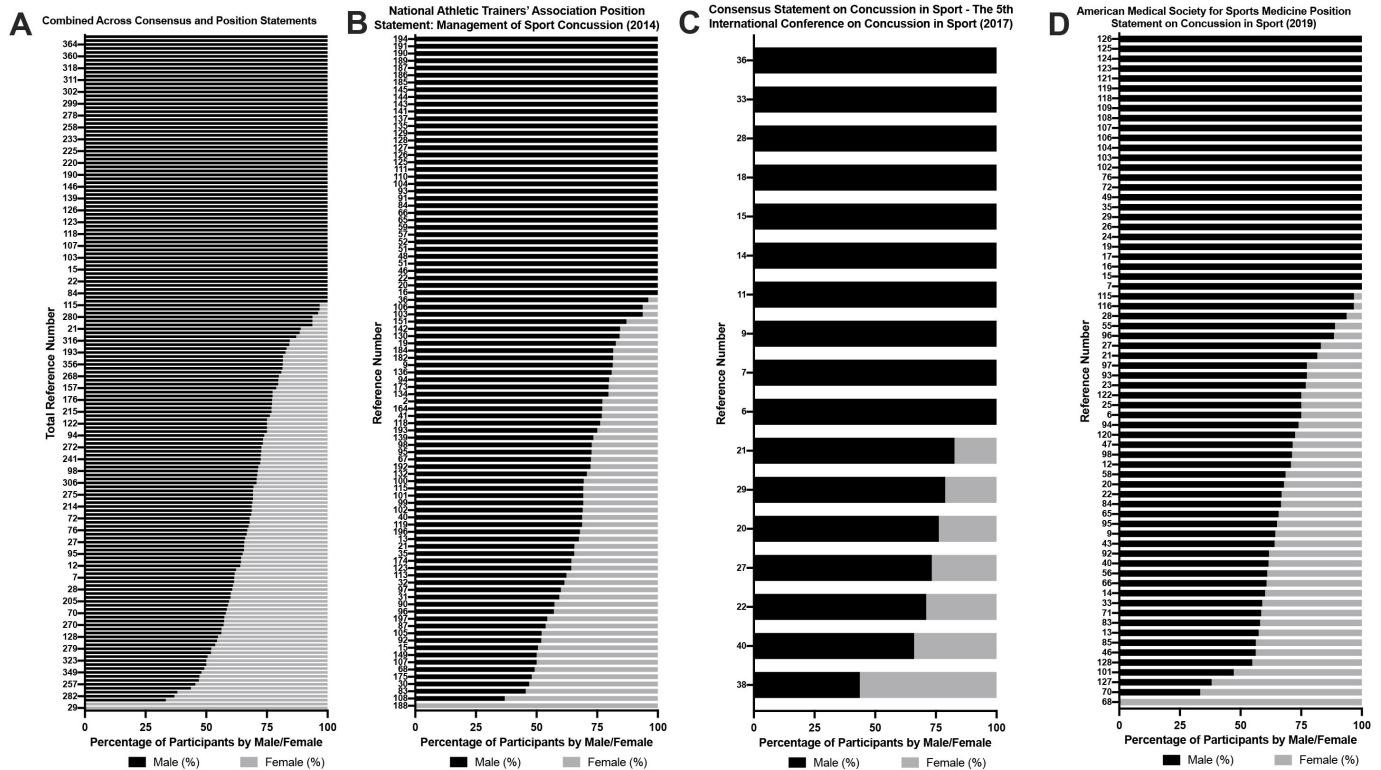
**Figure 3** Studies included in the three statements as binned into different male and female athlete compositions. Each column indicates the number of cited studies in that group as well as the percentage it represents (in parentheses).

such as the NCAA Injury Surveillance program<sup>51</sup> and the high school RIO database,<sup>59 60</sup> have also made substantial strides towards equal representation by sex. Consensus and position statements rely on the evidence available at the time, which naturally lags behind some of these efforts. Still, financial support and logistical assistance for concussion research originating from heavily male sports organisations may continue to influence the concussion research gender composition. As new areas of concussion research emerge, we must consider targeted efforts towards preventing these imbalances in new subfields.

Other systemic influences outside sport may also encourage more focus on men in concussion research to the detriment of women's concussion care. Across the sciences, there is a preponderance of male faculty,<sup>61</sup> especially in research roles,<sup>62 63</sup> which may bias the selection of male athletes included in research as it has in other domains.<sup>64 65</sup> Both the Centers for Disease Control and Prevention and the National Institutes of Health (NIH)

have instituted guidelines for inclusion of women and female sex model organisms in animal research to ameliorate past inequities.<sup>66 67</sup> Research samples that contain insufficient diversity to inform care for diverse populations<sup>68</sup> may lead to poorer care for undersampled populations (eg, African-American children and asthma).<sup>69</sup> Along these lines, men and women clinically differ in adverse drug responses,<sup>70</sup> substance abuse,<sup>71</sup> and even susceptibility to multiple sclerosis<sup>72 73</sup>—the last of these raising the possibility that long-term effects of concussions on white matter may also differ between male, female, transgender or non-binary athletes.<sup>74</sup> Given the considerable known differences in concussions between male and female athletes, only more consistent inclusion of women in ongoing research will create the commensurate evidence base for equitable clinical care.

Funding agencies, researchers, clinicians and other stakeholders should collectively extend efforts toward supporting



**Figure 4** Percentage of male and female participants across individual studies cited across all statements (A) and in the three organisational statements (B–D). Each statement was ranked by percentage of female/male athletes for facilitated visual comparison, starting with 0% female athlete studies at the top. Each column represents one study referred to by that consensus statement's reference number on the left axis (eg, reference #191 in NATA 2014). Reference numbers for each study in the combined graph are available in online supplemental file 2. NATA, National Athletic Trainers' Association.

female athletes in concussion research. We have identified several strategies:

1. Balancing the representation of female, male, transgender and non-binary authors on consensus and position statement voting and authorship teams—as well as within editorial boards and research programme management.
2. Female athlete-focused sections of consensus and position statements should be included until the literature is robust enough for a standalone document for this population.
3. Consensus and position statements should acknowledge when predominantly male athlete samples inform recommendations.
4. Include a checkpoint within consensus/position statement processes for ensuring that cited research is as balanced as possible (similar to NIH's 'Inclusion of Women and Minorities' requirements).
5. Create research funding opportunities that focus solely on women or non-binary and transgender athletes or, at a minimum, include a better balance between male and female athlete data.

### Limitations

A sample of the concussion literature based on the consensus statements may capture the most clinically relevant literature but also incurs certain limitations. First, this analysis spans a wide temporal window—including a time period where biological sex and gender were persistently conflated; our analysis must accommodate this inconsistency between self-reported gender and biologically determined sex but crucial differences could be missed with this oversight. Second, these statements, by

definition, lag behind the most current work and could misrepresent the current state of research. Third, research outside of the consensus-cited literature could show systemically less (or more) inclusion of female athletes into the concussion literature which would not be reflected in our study. In addition, while these statements all include recommendations for paediatric populations, they are not specifically aimed at that population and a paediatric-specific study on male-female athlete bias may find significant differences from the current document. Finally, this analysis includes an assessment of female athlete inclusion in the general concussion literature, but does not perform this task with paediatric or geriatric populations, general traumatic brain injury, non-binary athletes, athletes with disabilities, athletes of colour, lower socioeconomic status (SES) athletes, athletes outside of Western industrialised nations, native and First Nations athletes, or any other number of different athlete demographics. Further work should seek to create greater inclusion among all demographic dimensions within the concussion literature to assure just distribution of the benefits of research. The current method of this paper—analysing the data from systematic expert-authored reviews—may be an efficient way to assess broader scientific trends as the drastic increase in the research literature makes repeated systematic reviews less feasible.

### CONCLUSION

Researchers and funding agencies should acknowledge that passive approaches to concussion research recruitment will result in continued under-representation of female athletes. Instead, concerted inclusion efforts must be made to sample athlete populations in a way that allows an equitable

representation of diverse athletes in concussion research. Better female and non-binary athlete-focused concussion research data will narrow the knowledge gap between male and female athletes and ultimately allow better data-driven care for all athletes.

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