Research Article

# Reporting the Influence of Sex in Research: Trends at AAOS Annual Meetings

Ashley Tisosky, MD
Catherine Logan, MD
Emily M. Brook, BA
Jen Xu, BS
Elizabeth Matzkin, MD

## Abstract

**Background:** Several initiatives have urged the inclusion of sex in data analysis, but few studies have examined the prevalence of sex-specific reporting in musculoskeletal research. This study aims at determining the presence of sex-specific analyses reported in research at American Academy of Orthopaedic Surgeons Annual Meetings.

**Methods:** Abstracts listed in the American Academy of Orthopaedic Surgeons Annual Meeting programs from 2006 to 2013 were retrospectively reviewed for the presence of research reporting the results of a sex-specific analysis.

**Results:** The number of abstracts reporting a sex-specific analysis increased from 48 (2006) to 117 (2013) but accounts for 5.4% of research presented from 2006 to 2013. Hip and knee arthroplasty literature accounted for 37% of included abstracts.

**Conclusions:** The reporting of sex-specific analyses has improved over time but accounts for 5.4% of research presented at annual meetings from 2006 to 2013. The inclusion of sex-specific analyses should be required for future research publications to better understand the influence of sex in musculoskeletal medicine.

From Harvard Combined Orthopaedic Residency Program (Dr. Tisosky and Dr. Logan), the Department of Orthopaedic Surgery (Ms. Brook and Dr. Matzkin), Brigham and Women's Hospital, and Harvard University (Ms. Xu), Boston, MA.

Correspondence to Dr. Matzkin: ematzkin@bwh.harvard.edu

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Historically, women and children were excluded from research trials to offer them protection from any potential negative consequences. In 1985, the United States Public Health Service Task Force on Women's Health Issues concluded that omission of women from research studies led to a lack of evidence-based knowledge about women's health and negatively affected their medical care.[1] It was not until 1993 that these guidelines were transformed into law with the passage of the National Institutes of Health (NIH) Revitalization Act, which mandated the inclusion of women and minorities in clinical research.[2] Shortly after, the FDA, Agency for Health Research and Quality, and Centers for Disease Control and Prevention developed similar guidelines.[3-5] In 2015, a General Accounting Office audit found that 57% of enrollees in phase III clinical trials were females and that greater than 90% of grant proposals submitted met the standards for inclusion of female subjects.[6]

Despite the substantial progress that has been made with regard to the equal inclusion of both sexes as subjects in federally funded research, subsequent sex-specific data analysis and reporting of findings remains low.[7] The NIH policy on the inclusion of women and minorities in research states, "the inclusion of the results of sex/gender, race/ethnicity, and relevant subpopulations analyses is strongly encouraged in all publication

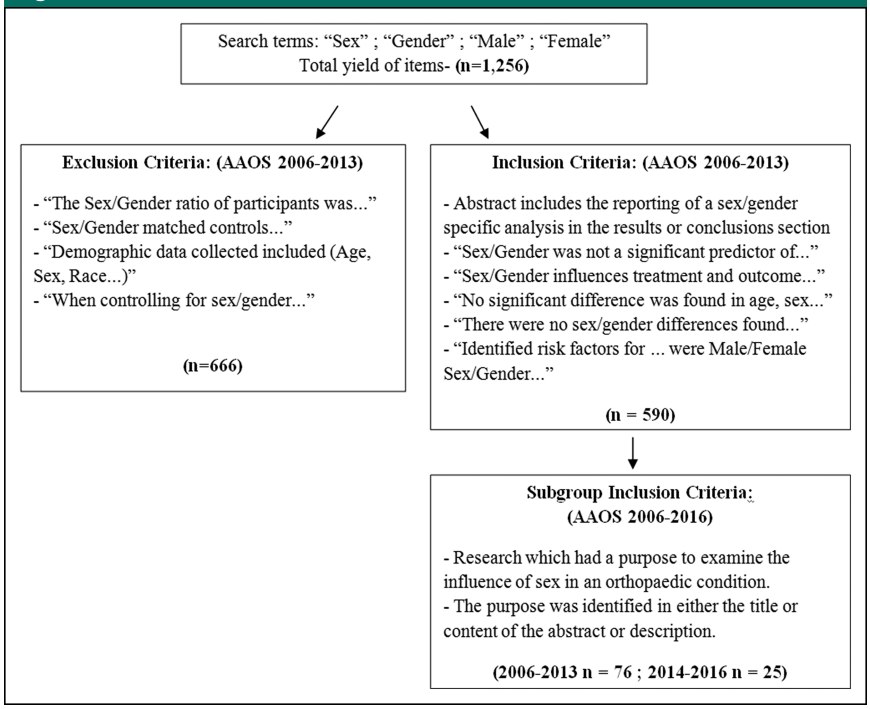
submissions. If these analyses reveal no differences, a brief statement to that effect, indicating the groups and/or subgroups analyzed, will suffice."[2] In 2014, the NIH further developed new policies requiring researchers to report their plans for the balance of male and female cells and animals in preclinical studies in all future applications.[8] Compliance of sex and gender inclusion in research funded by the agency is then monitored through data-mining techniques. Although the NIH cannot directly control the publication of sex and gender analyses, it continues to partner with publishers to promote the publication of such research results.[9,10]

In an effort to address this policy, some journals have modified their editorial policies to require the reporting of sex-specific results.

Sexual dimorphism is well known in several musculoskeletal conditions. Anterior cruciate ligament (ACL) injury is up to 10 times more likely in females and is caused by a multitude of factors, including hormonal involvement, neuromuscular control, and anatomic variations.[11-13] The risk of osteoporosis and fragility fractures is substantially greater in females compared to males, attributable to hormonal differences.[14-16] In addition, several studies have demonstrated sex differences in the development of osteoarthritis and cartilage loss over time.[17-19]

Although several orthopaedic conditions have been specifically studied with regard to sex differences, a call for the inclusion and reporting of sex-specific analyses in all orthopaedic research has been proposed. A 2014 editorial in *Clinical Orthopaedics and Related Research* recommended that studies be sufficiently powered to answer research questions for both sexes and that the influence of sex on study results must be analyzed and reported.[20] The primary purpose of our study was to determine the presence of research reporting the results of a sex-specific analysis at the American Academy of Orthopaedic Surgeons (AAOS) Annual Meetings from 2006 to 2013. We hypothesize that the number of research abstracts that report the results of a sex-specific analysis will be low, despite NIH and several high-impact journal initiatives that encourage the inclusion of sex-specific analyses in research results.

**Figure 1**




Schematic showing inclusion and exclusion criteria for research presented at the 2006 to 2016 AAOS Annual Meetings. AAOS Annual Meeting years of 2014 to 2016 could only be evaluated for inclusion in the subgroup because of a change in the program format. AAOS = American Academy of Orthopaedic Surgeons

## Methods

### Sample and Procedure

Abstracts listed in the AAOS Annual Meeting final program over a 7-year period (2006 to 2013) were retrospectively reviewed to determine the presence of research reporting a sex-specific analysis. A key word search within paper, poster, and scientific exhibit presentations was performed using the terms "sex," "gender," "male," and "female" in each AAOS Annual Meeting program. Historically, publications have incorrectly used the terms "sex" and "gender" to describe differences between males and females in research. The reason for such an inconsistency is due to a lack of knowledge about the difference between the terms sex and gender. Sex is defined as the biologic classification of living things as male or female according to their reproductive organs and functions assigned by the chromosomal complement.[21] Gender is defined by a person's self-representation as a male or female or how that person is responded to by social institutions on the basis of the individual's gender presentation.[21] Because these terms have been inconsistently used in the literature, both sex and gender were used as key words.

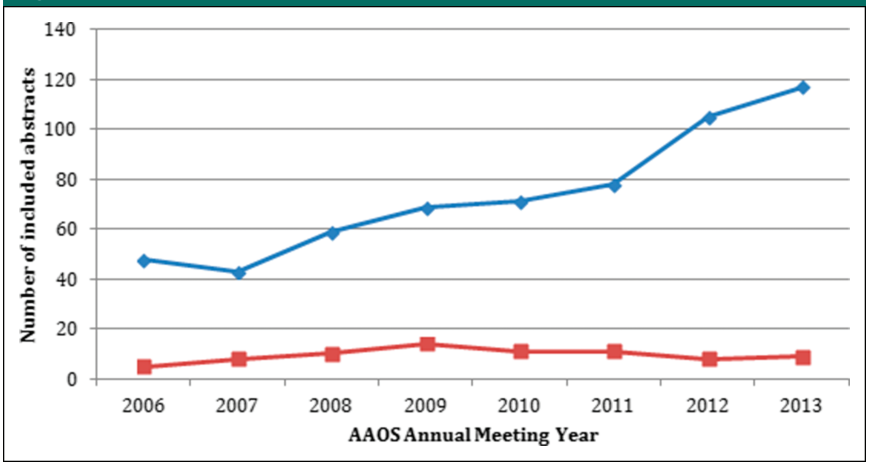
**Table 1**

**Number of Abstracts That Met the Inclusion Criteria by Each AAOS Annual Meeting Year**

| AAOS Annual Meeting Year | Included Abstracts (n = 590) | Abstracts Focused on Sex Differences (n = 101) |
|---|---|---|
| 2006 | 48 | 5 |
| 2007 | 43 | 8 |
| 2008 | 59 | 10 |
| 2009 | 69 | 14 |
| 2010 | 71 | 11 |
| 2011 | 78 | 11 |
| 2012 | 105 | 8 |
| 2013 | 117 | 9 |
| 2014 | — | 7 |
| 2015 | — | 8 |
| 2016 | — | 10 |

AAOS = American Academy of Orthopaedic Surgeons

**Figure 2**




Graph showing included abstracts (blue) and abstracts that specifically evaluated the involvement of sex in an orthopaedic condition (red) over the 2006 to 2013 AAOS Annual Meeting years. AAOS = American Academy of Orthopaedic Surgeons

All abstracts from the 2006 to 2013 AAOS Annual Meetings that contained one or more of the above key words were reviewed for inclusion and exclusion criteria (Figure 1). In 2014, the AAOS Annual Meeting program format changed from including a full structured abstract to a single paragraph summary of each presentation. Consequently, research from the 2014 to 2016 AAOS Annual Meetings was not able to be included in the primary group analysis because the data were not comparable to years 2006 to 2013, and reporting of sex-specific analysis may have been underreported because of length restrictions, particularly if the impact of sex was not a primary outcome.

Abstracts from the 2006 to 2016 AAOS Annual Meeting years were further evaluated for inclusion in a subgroup, which comprised research with an explicit purpose of evaluating the influence of sex on an orthopaedic condition (Figure 1). Examples include: "Evidence for gender-related differences in absolute risk of death after hip fracture: meta-analysis" (2008) and "Gender differences in human knee function during maneuvers associated with non-contact ACL injury" (2011). The 2014 to 2016 AAOS programs were included in this subgroup analysis because the primary outcomes that were investigated remain clearly stated in the abbreviated paragraph, regardless of the overall program format change. Research from 2014 to 2016 was added to provide the most updated data on the topic of sex-specific analysis in orthopaedic research.

## Measures

The abstracts that met the inclusion criteria were totaled for each AAOS Annual Meeting year (2006 to 2013) and divided by the overall number of research presentations to evaluate the prevalence of orthopaedic research reporting the results of a sex-specific analysis. In addition, research that had a purpose to evaluate the involvement of sex in an orthopaedic condition was summed for the 2006 to 2016 AAOS Annual Meeting years. Included abstracts and abstracts that met the subgroup criteria were summed for each meeting year. In addition, included abstracts were categorized by subspecialty.

## Results

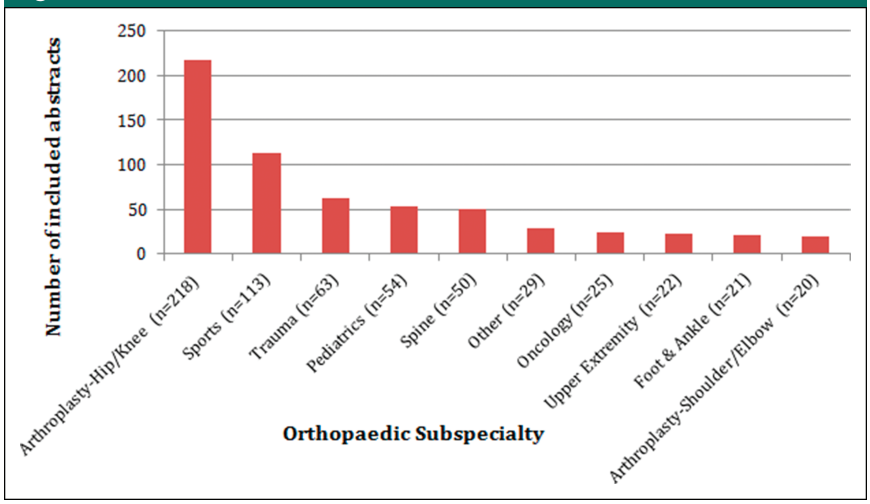
The key word search for "sex," "gender," "male," and "female" yielded 1,256 items throughout the 2006 to 2013 AAOS Annual Meeting programs. Of the search items, 590 abstracts reported a sex-specific analysis, and 101 abstracts had a purpose to evaluate the influence of

**Table 2**

**Number of Included Abstracts and Abstracts That Had a Purpose to Examine the Influence of Sex in an Orthopaedic Condition by Presentation Format**

| Presentation Format | Included Abstracts (n = 615) |
|---|---|
| Paper | 340 |
| Poster | 246 |
| Scientific exhibit | 29 |

**Figure 3**




Graph showing the distribution of included abstracts based on orthopaedic subspecialty.

sex on an orthopaedic condition (Figure 1). The number of abstracts that reported the results of a sex-specific analysis increased over time, from 48 abstracts in 2006 to 117 in 2013 (Table 1; Figure 2). The most significant increase by Annual Meeting year was from 2011 (n = 78) to 2012 (n = 105; Table 1; Figure 2). Abstracts included in the subgroup (n = 101) did not notably increase over time (Figure 2). Only 5.4% of the 11,001 papers, posters, and scientific presentations presented at AAOS Annual Meetings from 2006 to 2013 reported the results of a sex-specific analysis. The categorization of included abstracts by presentation format is shown in Table 2.

By subspecialty, the largest demonstration of sex-specific analyses was in hip and knee arthroplasty, representing 37% (n = 218) of included abstracts, followed by sports medicine with 19% (n = 113), trauma with 11% (n = 63), pediatrics with 9% (n = 54), and spine with 8% (n = 50). The remaining subspecialties each represented less than 5% of abstracts with sex-specific analyses (Figure 3).

## Discussion

Sexual dimorphism has been well studied in several areas of musculoskeletal medicine including ACL injury, osteoporosis, and osteoarthritis. Despite the growing body of literature concluding distinct differences between the sexes in musculoskeletal conditions, the inclusion of sex-specific analyses in all orthopaedic-related research is lacking. One previous study investigated the proportion of research reporting sex-specific analyses in high-impact orthopaedic journals from 2000 to 2010 and found that although the presence of sex-specific analyses increased over the study period, less than a third of studies reported a sex-specific analysis in 2010.[7] Similarly, our study demonstrated that the reporting of sex-specific analyses has increased over time, from 48 abstracts in 2006 to 117 abstracts in 2013. Nonetheless, only 5.4% of the 11,001 abstracts presented at the 2006 to 2013 AAOS Annual Meetings reported the results of a sex-specific analysis.

By subspecialty, hip and knee arthroplasty accounted for 37% of research reporting the results of a sex-specific analysis. Although the volume of sex-specific arthroplasty research at AAOS Annual Meetings has increased steadily over time, the focus of that research and distribution by anatomic region has varied considerably. In 2008, 65% of sex-specific arthroplasty abstracts were focused on the knee (n = 13). In addition, of the eight abstracts for which the purpose was to investigate the influence of sex in an orthopaedic condition, four focused on the gender-specific knee replacement implant. This increased trend in sex-specific analyses is likely due to the marketing of a gender-specific total knee arthroplasty implant first reported in the literature in 2007.[22] Advocates cited the numerous morphologic differences between male and female knees as the driving force for development and utilization of sex-specific knee arthroplasty components.[23] Opponents highlighted no difference in implant survivorship and functional outcomes between the sexes when using standard components.[24] This debate spurred interest in researching not only the anatomical variations between males and females but also research focusing on the potential sex differences in the clinical outcomes of total joint arthroplasty.

In 2012, there was another notable increase in the number of hip and knee arthroplasty abstracts that reported the results of a sex-specific analysis. This increase was likely

associated with the rising interest in metal-on-metal (MoM) hip resurfacing and total hip arthroplasty, as well as the influence of sex on outcomes.[25,26] The use of MoM articulations in total hip arthroplasty was originally favored because of improved postoperative stability using large femoral heads and low volumetric wear rate. However, high short-term failure rates and numerous adverse events including development of aseptic lymphocyte-dominated vasculitis-associated lesions, pseudotumor formation, elevated serum cobalt and chromium ion levels, and soft-tissue destruction lead to a sharp decrease in popularity of the MoM bearing. Female sex has been identified as a risk factor for elevated serum metal ion levels.[27] Elevated chromium ion levels greater than 7 parts per billion are associated with markedly worse health-related quality of life and hip function in female patients with MoM bearings, both hip resurfacing and total hip arthroplasty.[28] The surge in sex-specific analyses in total hip arthroplasty research at this time is likely related to investigation of the various adverse effects of MoM bearings and specific risk factors for those complications, including sex.

Sports medicine contained the second highest percentage (19%) of sex-specific reporting. Most of this literature focused on sex differences in ACL injury and outcomes after reconstruction.[11-13] Trauma represented 11% of abstracts with sex-specific analysis and encompassed the most diverse spread of orthopaedic topics. Research with sex-specific analyses ranged from appropriate management of unique patient populations including polytrauma and geriatric patients, recognition of metabolic bone disorders such as vitamin D deficiency, and atypical diphosphonate-related femur fractures, as well as the treatment and outcomes of various upper and lower extremity fractures. Sex-specific reporting in pediatric orthopaedics (9%) was predominantly focused on adolescent idiopathic scoliosis. Other topics included cerebral palsy and trauma. Last, 8% of the abstracts with sex-specific analyses were found in the field of spine surgery, primarily reporting on degenerative cervical and lumbar disease, outcomes after spinal fusion, and the use of various fusion adjuncts including bone morphogenetic protein-2.

The primary limitation of this study is that only the abstract was available for review in the AAOS Annual Meeting program. Abstracts that did not explicitly state the outcome of a sex-specific analysis were excluded, even if demographic data were collected, because there was no method to confirm that a sex-specific analysis was actually performed. It is possible that some presentations did include the reporting of sex-specific analyses, but did not incorporate such findings into the abstract. This may be due to the lack of results significant enough to warrant appearance in the abstract in conjunction with length restrictions. This limitation may have underestimated the number of presentations that performed a sex-specific analysis. Nevertheless, our primary purpose was to determine the prevalence of sex-specific reporting in AAOS Annual Meeting abstracts as a proxy for the orthopaedic research community. Including abstracts that did not specify an analysis of sex may have resulted in misleading data. We were unable to review complete abstracts for the reporting of a sex-specific analysis beyond 2013 because of a change in the AAOS program format, which printed only a short summary of the research in place of the full abstract. We chose to include presentations from the 2014 to 2016 AAOS Annual Meeting programs in the subgroup analysis to provide the most up-to-date information on the topic of sex-specific research. The subgroup encompassed presentations that specifically focused on the effect of sex on an orthopaedic condition, which is evident in the title and summary paragraph regardless of program format change.

## Conclusions

Although the overall number of research abstracts reporting a sex-specific analysis has improved over the study period, research that reported sex-specific analyses accounted for only 5.4% of research presented at the 2006 to 2013 AAOS Annual Meetings. Furthermore, research that focused primarily on the effect of sex on an orthopaedic condition comprised less than 1% of the presentations at the AAOS Annual Meeting in 2016 (n = 10; 0.7%). In line with the NIH policy dictating that all applications must state how female and male subjects will be balanced, the AAOS should require authors to specifically indicate whether a sex-specific analysis was performed. Because of limitations on abstract word count, this may be as simple as adding a check box to the application form.

As clinical investigators, we must include the results of sex-specific analyses in all studies. It is imperative that we continue to understand the importance of sexual dimorphism in musculoskeletal medicine. The NIH has continued to develop new policies to further mandate balance of male and female subjects in preclinical studies. As preclinical studies continue to advance the inclusion of sex differences analysis, clinical scientific reporting should intuitively follow the same guidelines to provide the most accurate conclusions. The time has come for journals and editorial boards to require the reporting of sex-specific analyses in all published research. This will serve to strengthen not only

the musculoskeletal literature but also the field orthopaedic surgery as a whole, enabling us to provide all our patients with optimal evidence-based care.

## References

*Evidence-based Medicine:* Levels of evidence are described in the table of contents. In this article, references 1-3 are level I studies. References 7, 11, 15, 23, 24, 26, 28 are level II studies. References 16, 17, 19, 22, 25, 27 are level III studies. Reference 13 is a level IV study. References 4-6, 8-10, 12, 20, 21 are Level V reports or expert opinions.

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