Assessing the Accuracy of Biological Sex and Gender Identity Terminology Usage in Ergonomics Research: A Scoping Review

Submitted by

Abigail Gualtieri

Wellness and Health Promotion

To

The Honors College

Oakland University

In partial fulfillment of the

Requirement to graduate from

The Honors College

Mentor: Dr. Tara Diesbourg, Assistant Professor

Environmental Health and Safety

Oakland University

April 7, 2023

Abstract

Introduction

Ergonomics research sometimes incorporates biological sex and gender identity in order to assess their influence on workplace health and safety recommendations. Currently, researchers are discussing how to best include sex and gender. However, there is a lack of discussion on whether these terms are being used accurately when they are. Therefore, the purpose of this research is threefold: 1) to understand how biological sex and gender identity are currently used in ergonomics research, 2) to evaluate the accuracy of this use, and 3) to provide recommendations for future research. With this work, I aim to answer the following question: "How accurate is ergonomics research in the way it considers biological sex and gender identity?"

Methods

I conducted a scoping review of ergonomics research that studies biological sex and gender identity. I evaluated how sex and gender terms were used throughout research and how accurate this use was. I screened database results using filters, evaluating article titles, reading study abstracts, and extracting relevant information from full research articles. I recorded uses of sex and gender terms in each included article in order to identify trends and assess accuracy.

Results

The results of my scoping review indicated that ergonomics research does not apply biological sex or gender identity concepts correctly. Specifically, sex and gender were frequently treated synonymously and their terms were used interchangeably. Also, gender was discussed more frequently than sex, although physical characteristics were discussed more than social ones.

Discussion

Although gender may not always be necessary to discuss in ergonomics research, sex-based differences are extremely important considerations. When communicating these sex-based differences, it is imperative that this is done accurately, in order to ensure that all readers, especially those affected by this research, are able to understand and apply its findings. The results of this analysis revealed that sex and gender terminology are almost always used incorrectly in ergonomics research. Ergonomics research failing to apply biological sex and gender identity correctly could lead to misunderstanding and misinterpretation of the subsequent recommendations. If sex and gender are conflated, findings could be interpreted as being relevant to one group although they were meant for another. Also, gender is not necessary to discuss in ergonomics research that aims to identify physical or biological traits. However, if social differences are discussed, all possible gender identities should be included so ergonomics can help the greatest number of people.

Recommendations

Ergonomics research should aim to be more accurate while discussing biological sex and gender identity. Sex and gender should be used properly, discussed separately, and gender should only be discussed in social contexts acknowledging all gender identities, rather than just men and women.

1. Introduction

Ergonomics is “the scientific study of people and their working conditions, especially done in order to improve effectiveness” [1]. Sometimes, its research incorporates variables such as biological sex or gender identity to assess their influence on ergonomics results and subsequent recommendations. Libretexts Medicine explains that biological sex is assigned to a person at birth, and is determined by a variety of traits including chromosomes, internal and external reproductive anatomy, hormone levels, and hormone expression. Most commonly, these traits align fully with either the male or female sex, but almost 2% of the population’s traits do not. This 2% is classified as intersex [2]. On the contrary, gender is defined as “A social construction… based on labels of masculinity and femininity; gender identity is a personal, internal perception of oneself…an individual may see themselves as a man, woman, having no gender, as having a non-binary gender [or more]” [3].

Current research focuses on making the use of sex and gender in ergonomics as effective as possible. This is because it has already been established that sex and gender can be beneficial to research by addressing potential differences between groups rather than providing “one size fits all” recommendations [4-6]. Therefore, research can transition to studying how sex and gender should be included, instead of if it should be included. One study found that, when trained on including sex and gender properly, ergonomics interns supported the concept but struggled to utilize them beyond demographic markers [7]. Another study recommended training on sex and gender that moves beyond anthropometry to include social aspects and other aspects of the workplace such as business and marketing [6]. Recent research also suggests focusing on women and/or females to incorporate sex and/or gender because this population is relatively new to the workforce [8-10]. This includes considering physical differences between

males and females, division of labor between men and women, and social difficulties specific to women and/or females [8-10].

One study found that addressing sex and/or gender as study factors is more effective at creating policy changes, while implicitly mentioning sex and gender (i.e. that they were controlled for or as unrelated participant demographics) is more effective at making changes in the workplace itself [4]. Similarly, another study found that including sex and gender in ergonomics was more impactful in creating public conversation about these topics than in creating change in daily workplace practices, even when specific recommendations were provided [5].

Given this increased push to include sex and gender in ergonomics, current literature is lacking a thorough examination regarding the accuracy in using sex and/or gender in ergonomics research. If sex and/or gender are conflated, it could mean misidentifying employees and subsequently providing inappropriate ergonomics initiatives [11]. If employees are misidentified by ergonomists, they might follow recommendations for what they think is their group but they were actually made based on research findings from another. Also, if research assumes that there are only two genders and/or sexes, or that all people identify with the gender they were assigned based on sex, it will exclude people who are transgender, agender, non-binary, or intersex [12]. It is estimated that 1.3 million adults report identifying as transgender but this is likely a low estimation of the true population because survey wording is often incomplete, or participants are not comfortable disclosing their identity [13]. It is also rare that agender, non-binary, or intersex individuals are counted at all [13]. This implies that it is hard to know the exact number of non-cisgender and/or intersex individuals, however, the statistics that have been published suggest that these people exist and, therefore, deserve to be included in ergonomics research.

Therefore, the purpose of this research is threefold: 1) to understand how biological sex and gender identity are currently used in ergonomics research, 2) to evaluate the accuracy of this use, and 3) to provide recommendations for future research. With this work, I aim to answer the following question: “How accurate is ergonomics research in the way it considers biological sex and gender identity?”

2. Methods

I conducted a scoping review of ergonomics research pertaining to biological sex and/or gender identity. I established my search databases as Oakland University, Cochrane, PubMed (which includes MedLine), and Web of Science. Search terms included “ergonomics biological sex,” “ergonomics gender,” and “ergonomics intersex”. Inclusion criteria required that the papers were published in peer-reviewed journals, in English, during the past 10 years (2012-2022), that the research was original research (no reviews of literature or meta-analyses) conducted in North America, and that the research focused on ergonomics, taking into account sex and gender differences among workers.

In this study, I define sex and/or gender terms in the published research as including the words “sex”, “gender”, “male”, “female”, “men”, and “women”. Further, appropriate sex terms are male and female while appropriate gender terms are men and women.

Searching and Screening Database Results

First, I searched each database for keywords "ergonomics biological sex," "ergonomics gender," and "ergonomics intersex." Then, I repeated the initial searches with added filters. I applied filters based on which ones were available for each database and were applicable to the inclusion criteria. Next, I screened the resulting titles. Specifically, I kept titles that included sex and/or gender terms, included an indication that they studied ergonomics, and did not violate the rest of the inclusion criteria. Finally, I screened the abstracts of the articles that were kept based on title, keeping articles that met my inclusion criteria. Figure 2.1 outlines the steps I took to screen the search results and determine the articles included in this review.

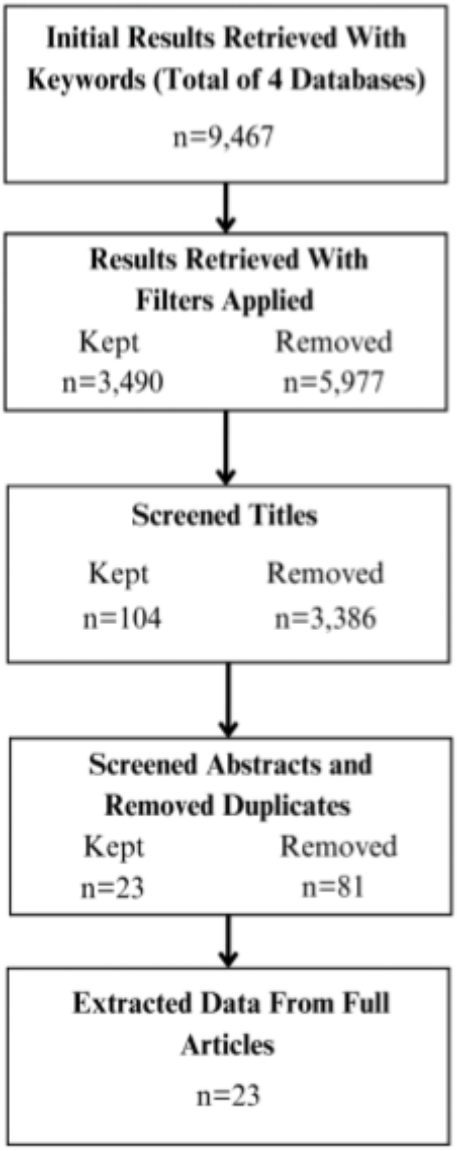

Figure 2.1
Steps undertaken in this analysis as well as the total number of results kept and removed at each stage of screening.

Extracted Data from Full Articles

I reviewed the 23 retained results in full to extract usages of sex and/or gender terms. First, I recorded which sex and/or gender terms were used in each title. Then, I searched every article for each sex/gender word and recorded which ones were used at least once. I used these results to count how many articles used the same combinations of terms to and track term usage throughout each article.

I identified whether each article aimed to study differences in sex or differences in gender. I also recorded how each study grouped participants (i.e. males vs females, men vs women, etc.). I compared each article's aim to its participant grouping and evaluated accuracy based on sex and gender definitions specified in the introduction.

I recorded each time an article attributed either social or physical characteristics to sex or gender (i.e. "because women have larger hips..." attributes a physical difference to gender). If an article made an attribution at least once, it was counted once towards that type. Because some articles made either multiple attribution types or none at all, the counts for this result do not equal the total number of articles included in my review.

Finally, I recorded specific instances of sex and/or gender term usage throughout each article. This included general notes about the implication, context, and accuracy of each use. Then, I used this information to evaluate the overall accuracy of every article by sorting usage into categories of incorrect and correct. I recorded the number of articles that had all correct instances, all incorrect, mostly correct (more than 50% correct), and mostly incorrect (more than 50% incorrect).

3. Results

Searching and Screening Database Results

The search term "ergonomics gender" populated the most results across all databases, followed by "ergonomics biological sex," and"ergonomics intersex" had the least results across all databases. Table 3.1 details the exact number of initial search results that populated in each database for every keyword searched. The total number of results from all databases was 9,467.

Table 3.1: The number of results populated for each set of keywords and database.

Keywords Searched	Oakland University	Cochrane	PubMed	Web of Science
Ergonomics Biological Sex	687	4	120	9
Ergonomics Gender	3,888	35	3,340	1,319
Ergonomics Intersex	1	0	64	0
				Total: n = 9,467

Repeating the initial searches with added filters narrowed down the results. I applied filters 2012-2022, English, and peer-reviewed to Oakland University's database, 2012-2022 to Cochrane, 2012-2022 and English to PubMed, and 2012-2022, English, and open access to Web of Science. Table 3.2 outlines the exact number of results that populated for each filtered database for the keywords searched. The total number of results for all databases after filters was 3,490.

Table 3.2: The number of results populated for each set of keywords by filtered database.

Keywords Searched	Oakland University (2012-2022, English, peer-reviewed)	Cochrane (2012-2022)	PubMed (2012-2022, English)	Web of Science (2012-2022, English, open access)
Ergonomics Biological Sex	264	4	51	7
Ergonomics Gender	1,688	27	1,382	30
Ergonomics Intersex	1 (no filters)*	0 (no filters)*	36	0 (no filters)*
				Total: n = 3,490

* I could not apply filters to these searches because there were not enough initial search results.

Screening the filtered results based on their titles reduced the results to a total of 104. Table 2.3 details the number of titles that were kept for each database and keyword.

Table 3.3: The number of titles that were kept for their corresponding keywords and database after screening the titles for relevant inclusion criteria.

Keywords Searched	Oakland University	Cochrane	Pubmed	Web of Science
Ergonomics Biological Sex	14	0	4	1
Ergonomics Gender	60	0	24	1
Ergonomics Intersex	0	0	0	0
				Total: n = 104

After reading through each paper's abstract, I retained 23 of the remaining 104 titles because they met the rest of the inclusion criteria. Therefore, I rejected 81 articles based on the following observations: 23 articles were duplicates, 20 described research conducted outside of North America, 11 described literature reviews, 11 were other studies that assessed the use of sex and gender in ergonomics research, 6 did not study sex or gender, and 7 were behind a paywall that was inaccessible to my institution.

Data Extracted From Full Articles

Recording which sex and/or gender terms were used in each title revealed:

- 6 (26%) titles used the word sex only [14-19]
- 13 (57%) titles used gender only [20-32]
- 2 (9%) titles used both male and female [33, 34]
- 1 (4%) title used "female sex" only [35]
- 1 (4%) title used gender, men, and women [36]

Searching each full article for sex and/or gender terms revealed:

- 22 (96%) studies used gender [14-18, 20-36]
- 12 (52%) studies used sex [20-24, 27, 29-32, 34, 36]
- 18 (78%) studies used men [14, 16-20, 22-29, 31, 33, 35, 36]
- 17 (74%) studies used women [14, 16-19, 22-29, 31, 33, 35, 36]
- 21 (92%) studies used male [14-18, 20-25, 27-36]
- 22 (96%) studies used female [14-35]

Charting the terms used in each article revealed the number of studies that used the same sets of terms:

- 8 (35%) studies used all 6 terms [14, 16-18, 25, 28, 33, 35]
- 4 (17%) studies used gender, male, and female only [21, 30, 32, 34]
- 6 (26%) studies used all terms except sex (i.e. gender, men, women, male, and female) [22-24, 27, 29, 31]
- 5 (22%) studies used a miscellaneous but unrepeating set of terms [15, 19, 20, 26, 36]

Collecting what each article aimed to study (.ie. sex or gender) and comparing it to how participants were grouped revealed:

- 4 (17%) studies aimed for sex and grouped males and females [14-16, 35]
- 3 (13%) studies aimed for sex and grouped men and women [17, 19, 33]
- 10 (43%) studies aimed for gender and grouped males and females [20, 21, 23, 24, 28-32, 34]
- 3 (13%) studies aimed for gender and grouped men and women [25, 26, 36]
- 2 (9%) studies aimed for gender and did not establish clear groups [18, 22]
- 1 (4%) study aimed for gender and grouped males, females, and non-binary people [27]

Counting the number of articles that attributed social or physical characteristics to sex or gender revealed:

- 6 (26%) studies attributed physical characteristics to sex [14, 18, 25, 28, 33, 34]
- 3 (13%) studies attributed social characteristics to sex [15, 21, 33]
- 10 (43%) studies attributed physical characteristics to gender [15, 19, 20, 23-26, 36, 31, 32]
- 3 (13%) studies attributed social characteristics to gender [22, 25, 32]

Recording which sex and/or gender terms were used in each section of every article exposed how common it was to switch between sex terms and gender terms throughout one study. Trends showed that usage was ultimately inconsistent and tended to switch categories with no apparent reason, as if sex and gender were synonymous.

Recording specific instances of sex and/or gender term usage revealed the following incorrect usage counts:

- 11 (48%) studies used the words male and female but never sex [20-24, 27, 29-32, 34]
    - 0 (0%) used the words men and women but never gender
- 13 (57%) studies used male, female, men, and women interchangeably [14, 16-18, 22-24, 27-29, 31, 33, 35]
- 5 (22%) studies used one term for one category but switched between two for the other (i.e. only use men, never male, but use women and female interchangeably) [19, 20, 25, 26, 36]
- 8 (35%) studies used the phrase “both genders”, all of which were referring to males and females [20-22, 27, 29, 31- 33]
- 4 (17%) studies used the phrase “female gender” [22, 26, 27, 35]

- 1 (4%) study used the phrase “male gender” [22]
- 1 (4%) studies used the phrase “sex-gender” [18]
- 1 (4%) study used the pronoun she referring to females [29]
- 1 (4%) study asks for gender in its survey with response options of male, female, and non-binary [27]
- 1 (4%) study asks for gender in its survey with response options of men, women, and non-binary/third gender [29]
    - This study later uses the phrase “both genders”

Assessing the overall accuracy of each article revealed:

- 0 (0%) studies were completely correct
- 8 (35%) studies were completely incorrect [14, 17, 21, 23, 27, 28, 30, 31]
- 3 (13%) studies were mostly correct [15, 25, 34]
- 12 (52%) were mostly incorrect [16, 18- 20, 22, 24, 26, 29, 32-36]

Discussion

The purpose of my review was to understand how biological sex and gender identity are used in ergonomics research, evaluate how accurate that use is, and provide recommendations for future research. The results of my review indicated that ergonomics research generally misunderstands and therefore applies sex and gender terms incorrectly. For example, 20 (87%) articles used sex and gender terms either completely or mostly incorrect, only 3 (13%) articles were mostly correct, and 0 (0%) were completely correct. Another one of my findings was that sex and gender were almost always considered synonymous and their terms were used

interchangeably. Specifically, the terms gender, male, and female were used more than sex, men, and women and were often incorrectly associated with each other.

Interchangeable Use of Biological Sex and Gender Identity

Many articles used the terminology incorrectly because they did not differentiate between sex and gender. The Office For National Statistics explains that sex is a physical trait that includes biological labels like male, female, or intersex. Gender, however, is a social trait that includes identities like man, woman, non-binary, and more [3]. Therefore, studies used the terminology incorrectly if they associated the terms male or female with gender and/or the terms man or woman with sex. Some studies also used all six sex and gender terms without separation, used all terms except sex (gender, men, women, male, and female), or used a miscellaneous but unrepeating set of terms (ie. gender, sex, men, and female). Other studies that used the terminology incorrectly aimed to study differences in biological sex but grouped men and women (gender terms), aimed to study differences between gender groups but identified participants as males and females (sex terms), and one study that aimed to study differences in gender but used male, female, man, and woman interchangeably. I also found that some papers attributed social characteristics to sex, attributed physical characteristics to gender, used male, female, men, and women interchangeably, used one term for one category but switched between two for the other (ie. used male/men interchangeably but only female), used the phrases “female gender”, “male gender”, “sex-gender”, and the one study that used the pronoun “she” while referring to females.

All people are assigned a biological sex and gender identity at birth, with males assigned to be men and females assigned to be women [37]. This link between sex and gender could explain why the majority of the articles used the terms synonymously. Specifically, they assumed that all males are men and all females are women. However, some people no longer identify with

the gender they were assigned based on their sex, so they transition to another gender [37]. According to the University of Northern Iowa, "The term transgender woman describes someone who was assigned male at birth and identifies as a woman [and]... transgender man describes someone who was assigned female at birth and identifies as a man" [38]. This is why ergonomics research that assumed all males are men and all females are women were incorrect in their use of the terminology. While the studies may have intended to evaluate physical abilities based on sex, using gender terms interchangeably could change the way transgender workers follow recommendations. If their results indicate that the participant's gender is responsible for their physical capacity instead of their sex, the results could easily be misinterpreted and misapplied. This could lead to increased chances of workplace injury, especially for transgender individuals.

Overuse of "Gender"

Another finding in the ergonomics research papers was the overuse of the term gender. Gender was generally discussed more often than sex. For example, 14 (61%) titles used gender terms while only 9 (39%) used sex terms. Also, 22 (96%) studies used the term gender at least once, but only 12 (52%) of studies used the term sex. However, physical (sex) [3]differences were studied more often than social (gender) [3] differences. For example, 21 (92%) studies used the term male at least once and 22 (96%) studies used female, while only 18 (78%) studies used men and 17 (74%) studies used women.

The studies in my review can correctly apply sex and gender terms by using the words sex, male, female, and intersex while discussing physical traits and gender, man, woman, non-binary, and other gender identities if discussing social traits [11]. However, discussing social traits may not be necessary at all. Ergonomics research aims to assess physical capacity and use the findings to make recommendations for reducing workplace injuries like musculoskeletal damage [39]. Social identities like gender have no impact on a person's physical

capabilities [11], so they do not have to be considered by studies aiming to assess physical differences. Gender may have impacts in the workplace that could impact an employee's behavior and lead to injury, but it is not necessary to consider gender while evaluating inherent physical injury risk [11]. Ultimately, because the majority of the papers evaluated in this review studied physical differences, then sex terms should have been used more than gender terms.. However, the opposite was true, and gender was discussed more than sex.

Misunderstanding Gender Identities

Despite the recent push to include sex and gender in ergonomics research to foster inclusivity, gender is not likely relevant in physical ergonomics research [39]. However, when evaluating Total Worker Health and the impact of psychosocial risk factors on worker wellbeing, assessing how gender dynamics such as discrimination, harassment, or wage gaps could alter behavior and indirectly create risk for workplace injury may be important to consider. Some of the papers described in this analysis focused on these psychosocial risk factors in the workplace, and while gender identity should be considered in these studies, I found that it was not always applied correctly [21, 22, 24, 25]. Man and woman are the most prevalent gender identities, however, other known gender identities include having no gender identity (agender), identifying somewhere outside of the binary concepts of man and woman (non-binary), identifying with multiple genders (pangender or gender-fluid), a Native American identity encompassing both masculine and feminine spirits (Two-Spirit), and many more [12].

Any articles that discussed gender but failed to include possible identities other than men and women, did not use gender terminology correctly. Many articles used the word gender, but only 2 (9%) of them acknowledged non-binary gender identities, and 0 (0%) acknowledged any others. Furthermore, the 2 (9%) that mentioned non-binary identities applied the concept incorrectly. For example, one of them aimed to study differences in gender but grouped

participants by male, female, and non-binary [26]. While associating gender and non-binary is correct, male and female are sexes and should not be associated with the concept of gender or grouped with non-binary [3]. The second study more accurately aims to study gender and groups participants by man, woman, and non-binary/third gender. However, it describes its groups interchangeably with male and female and uses the phrase “both genders" [28]. Similarly, this study attempts to be inclusive by mentioning non-binary genders, but noting non-binary as the “third gender” is inaccurate as it is not the third and final gender [11]. Finally, it directly contradicts itself by giving more than two options for gender identification but later using the phrase “both genders.” Similar instances occurred in the 7 (31%) total studies that used the phrase “both genders,” although there are more than two recognized gender identities[11]. Furthermore, 4 (17%) of them were referring to males and females, which are sex terms.

Failing to acknowledge that there are more than two or three gender identities could alter the way that ergonomics results are interpreted by those directly affected by these findings. Individuals who identify as anything other than a man or a woman are automatically excluded from studies that say things like “both genders,” or only give options of man or woman. Therefore, workers might not be able to use ergonomics findings at all if their gender is not represented.

Correct Use of Sex and Gender Terms

While my findings indicate that sex and gender are generally applied incorrectly in ergonomics research, there were some instances of correct application. For example, some articles aimed to study sex and grouped males and females, some aimed to study gender and grouped men and women, others attributed physical characteristics to sex, and some attributed social characteristics to gender. While these are positive examples of sex and gender usage, it is important to remember that none of the articles applied sex and gender correctly all of the time.

Therefore, it could be possible that any correct usage was a coincidental outcome of using the terms interchangeably, rather than having a conscious understanding of the terms and applying them correctly purposely.

Limitations

One limitation of this work is that the Web of Science database was only used to search for open access filter publications. This is a limitation because open access was not actually a part of the inclusion criteria, and the filter was applied accidentally. While this should be considered while interpreting the number of results retrieved from Web of Science, there were a lot of duplicate results from all of the databases which subsequently had to be discarded, so the effect of this should be minimal because had the filter not been applied, Web of Science would have likely generated similar results to the other databases anyway. Ultimately, I was able to collect enough papers that I was able to get an understanding of the trends in using sex and gender terminology in ergonomics research.

Another limitation of this work is that, while the inclusion criteria specified work in North America, the majority of results were a result of work conducted in Canada. While this should be considered when considering my results, it did not impact my general findings. I searched for research in North America, and included what each database made available to me. The fact that the majority of the work comes from Canada does not dispel the need for increased accuracy while using sex and gender in the ergonomics research that was included in this review. Notably, there is a push in Health Sciences research in Canada to include sex and gender considerations in the research question. A government research and funding agency has been established to this end. It does, however, highlight the fact that more guidance on doing so properly is warranted, and that researchers in the USA should start considering the need for

including sex and gender in research, and to do so properly. Also, it is important to consider that the findings presented here may not be consistent in research outside North America and that other parts of the world may be better at using this terminology correctly.

Recommendations and Future Research

The results of my review indicate that current ergonomics research uses sex and gender terms incorrectly. My most prominent recommendation is for ergonomics research to become more accurate in its use of sex and gender terms. Sex and gender need to be acknowledged as separate concepts. Specifically, sex should only be associated with the terms male, female, and intersex while describing physical traits and gender should only be associated with terms like man, woman, non-binary, and other identities while discussing social characteristics. If research studies sex or gender it should be as accurate in these terms as it would be with any other terms or concepts. Therefore, I recommend that researchers educate themselves on these topics before including them as study variables.

Further, researchers could choose to study how to practically increase sex and gender accuracy in research. Example topics include finding the best education methods, ergonomist training practices, and standard definitions for sex and gender terms. Also, I recommend conducting additional literature reviews using different databases, including literature reviews and conference summaries, and studying regions outside of North America.

Future studies can also investigate the effects of hormonal replacement therapy on the relationship between biological sex and ergonomics recommendations. While my study acknowledges that biological sex is separate from gender identity, gender-affirming hormonal replacement therapy could have an impact on an individual's sex traits. Future research should

ask how to best incorporate these individuals in ergonomics recommendations and if hormonal replacement therapy affects research methods or results interpretations.

Conclusion

My scoping review revealed that biological sex and gender identity are not fully-understood or applied correctly throughout ergonomics research. My main findings were that sex and gender were treated synonymously and used interchangeably, gender was discussed when only sex was applicable, or gender was misunderstood when it was applied. Incorrectly using sex and gender concepts in ergonomics research not only makes some workers feel excluded, but it makes the research's recommendations easier to misinterpret. Because ergonomics aims to assess and reduce injury risk in the workplace, misapplication of the results can be dangerous as they might increase risk of physical injury. Ultimately, I urge ergonomics researchers to correctly identify the differences between sex and gender before studying these concepts in order to apply them correctly to research findings and subsequent recommendations.

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