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The Eternally Wounded Athlete: How Medical Professionals and Sports Injury Researchers Have Limited Female Athletes' Sport Participation and Biased the Interpretation of Sports Injury Research

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Abstract

Purpose of Review Female sports participation has long been diminished compared to male sports participation. This review contextualizes current findings in historical implicit gender bias.

Recent Findings The transition from the recognition of the Female Athlete Triad Syndrome to the Relative Energy Deficiency in Sport Syndrome (RED-S Syndrome) to the newly proposed Male Athlete Triad Syndrome demonstrates the power of implicit gender bias on sports injury research efforts, clinical practices, and policy decisions. Similarly, anterior cruciate ligament (ACL) injuries have long been portrayed as a young female athlete injury, a perception which has affected the sports medicine world in a way that has resulted in both male and female athletes not fully benefitting from possible research and clinical advances.

Summary This review explores the history of female exclusion from sport and considers how modern sport and exercise medicine has, perhaps because of implicit gender biases, inadvertently contributed to that exclusion.

Keywords Female · Athlete · Research · Sports-medicine · Implicit Bias

Introduction

Sports participation in the USA is a significant part of physical fitness, yet sport has been, for generations, considered a masculine preserve [1], as reflected in participation rates. Since 2012, more than 70% of children aged 6–12 are estimated to participate annually in team or individual sports, although girls and children from lower income homes are more likely either to quit or not participate [2]. At the high school level, almost 8 million students played organized high school sports, but girls constituted only 43% of athletes [3]. At the college level, of the roughly 500,000 athletes competing in National Collegiate Athletic Association institutions, just over 43% are female [4]. Although overall participation rates in sport have grown consistently for males and females since 1972, female participation rates have rarely gone above 43% and have never been proportional to the general female population. In adulthood, men are more than twice as likely to report playing recreational sports as women [5].

This essay explores the question of how this gender divide occurred in sport and what role sport and exercise medicine (SEM) may have played in contributing to it.

A History of Exclusion

For much of the history of the western world, women have been perceived as the weaker sex, physically smaller, and frailer than men. One origin story asserts that woman is a subset of man: the Bible explains that God made Adam and then made Eve from Adam's rib. Early in the seventeenth century, English settlers arriving in the "new world" were committed to a patriarchal social system founded on the belief that God had made women man's subordinate. Pamphlets in England and in the early USA about women asserted that

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because Eve bit the apple, God had punished all women with painful childbirth, even though reproduction was a woman's primary purpose [6]. Science defined women's bodies as different and lesser than men [7]. Women and girls were expected to perform physical labor such as necessary housework, but with the importation of enslaved people and extermination and removal of indigenous people, white women became increasingly privileged, and their health and reproductive abilities became doctors' focus. Few people cared about the health of women of color and poor immigrants [8, 9].

Life in the USA changed in the second half of the nineteenth century after the Civil War. The country's increased industrialization and urbanization caused a crisis of masculinity among middle-class and wealthy white men who no longer performed manual labor. The concept of muscular Christianity in the late nineteenth century promoted, among other ideals, the belief that a white man of status should be disciplined and physically strong [10]. President Theodore Roosevelt embodied the concept and credited his health to his sporting activities, including boxing and riding. He was a fan of organized contact, and thus manly, sports such as boxing and football [11]. Around 1880, the white middle-class male ideal of health was more muscular than in prior generations, and masculinity became increasingly tied to sport, which was just beginning its growth as a modern organization [12, 13]. Women's participation in early modern sport was limited to the wealthy and middle class who had the leisure to play, but their engagement tended to be in non-competitive formats, in homosocial settings, and appropriately demure attire [14, 15].

In the late nineteenth century, the medical profession made it clear that females, particularly wealthy white women, should limit their physical activity. Women participating in leisure activities at the end of the nineteenth century did so in part for eugenic reasons: doctors suggested that mild physical activity kept women in good health in order to bear healthy children, and the moneyed white community worried about the population growth of communities of color and of poorer people [14]. Reproduction was the central reason for women's being and for their health. Relying on theories about challenges of reproductive health, these largely white, male doctors saw menstruation as key to what they perceived as women's weakness. The onset of menstruation was an illness or wound which plagued women for decades, and once a month, women were urged to retire to recover from their menses. This basic assumption of abnormality impacted recommendations for physical activity and women's health [16].

Although some doctors encouraged prepubescent girls to play and exercise like their brothers in order to build strong, healthy bodies for future childbirth, the end of childhood ended such play. With puberty, energetic activity needed to cease immediately, and women needed to conserve energy for reproductive health. Activities such as fencing and golf might be acceptable for those who could afford them, but competition and vigorous activities were to be avoided as they put too much stress on the woman's mind and body. Even mild activity, though, was to be avoided during menstruation. During pregnancy, light walking and housework were still acceptable activities unless a doctor ordered bedrest. Only about 15% of women lived beyond their fertile years in the late nineteenth century; thus, doctors did not consider exercise for the postmenopausal [16].

The medical profession promoted fear that female sports participation was dangerous, particularly to women's reproductive health. A common assumption was that vigorous activity, such as jumping, would weaken the ligaments of the uterus, causing uterine displacement and infertility. The vitalist theory warned that women had a set amount of energy to grow and then maintain reproductive organs and that excessive energy use would impact future reproduction. Again, the medical profession was more concerned about white women of means than immigrants and women of color, and all women were thought to be healthier doing housework [17].

Separate and Unequal Sports

Not surprisingly given medical beliefs of the day, women were largely excluded from organized sport. Women were banned from the first modern Olympic games in 1896 just as they had been in the ancient Greek Olympic games. In 1900, when women were allowed to participate in some sports in the Paris games, the events were so low key the vacationing American who won the first Olympic gold medal for women's golf did not realize she was competing in an Olympic event [18].

When females were permitted in sports, events were altered or shortened to protect women's health [19]. After basketball was introduced in 1891 for men, the next year the physical director of Smith College modified the rules to make it safer for girls. She limited the game by creating zones on the court for the female players. This evolved into the "half-court" game in which three players from each team were on each side of the center court line, with three players from each team playing offense and defense exclusively. Supporters of the girls' half-court game argued the girls were too frail to run the court's full length [20]. Ironically, at least one doctor in 1982 tried to counter this perspective, asserting that forcing girls to stop their run at the half-court line (often in a jump-stop motion) put them at increased risk for knee injuries, but he blamed the knee injury risk on girls' weaker leg muscles [21]. Women's version of sport was almost always limited. In 1902, women's tennis matches were shortened to three sets from the men's five because the longer match was presumed dangerous to women's health. When female athletes reportedly collapsed in the infield at the 1928 Olympic games because they were perceived as too exhausted to move after the 800-m

race, the event was eliminated and not reinstated until 1960 when organizers decided women as a class were healthy enough to run that far. Women were not allowed to run the Olympic marathon until 1984 because it was too long [22, 23].

The basic premise that male bodies were stronger and better than women's bodies, justified by the medical community, resulted in formal division between male and female sports in the modern era [23]. When girls filed lawsuits in the late twentieth century US to gain access to male-only contact sport teams, defendants argued participation in the sport in question was too dangerous for the girl, relying on old medical truisms and some questionable research [20]. Further, female sports, separated from most male events, have also historically had limitations including time length, distance, equipment, and other rule changes based on the premise of female physical vulnerability to athletics. These issues persist in the present day.

Implicit Gender Bias in Sports Injury Research

Given historical limitations on women's sports participation due to unfounded medical beliefs, assuming SEM professionals harbor implicit gender bias is reasonable. Studies of implicit bias, biases involving associations outside conscious awareness that lead to unfair evaluations of people based on irrelevant characteristics such as race or gender, conclude that they influence clinician-patient interaction [24••]. Researchers and clinicians are as susceptible as the general public to perpetrating biased choices and actions, even when contrary to their explicitly held beliefs. Thus, evaluating the potential influence of gender bias in sports injury research is overdue. As Bekker et al. stated, "Why, in 2018, is SEM and its related disciplines still failing to identify and acknowledge the role that implicit bias plays in the very structure of our own research, practice and education? SEM is, after all, a profession that contains experts, and serves populations, of all genders" [25••].

Researchers pride themselves on objectivity, undergo extensive training on avoiding and managing bias using methodologic approaches, and submit their work to peer-review processes for further scrutiny. SEM researchers are expected to consider potential biases introduced during study subject selection, measurement of study variables, and data analyses. However, little thought has been given to the role that implicit gender bias may play in SEM research. Interpretation bias, an information-processing bias, is drawing inappropriate conclusions from research findings, even unbiased findings. Research interpretations influenced by implicit gender bias can be inappropriately used to drive future research, clinical approaches, and policy decisions, exacerbating the damaging effects of the initial bias.

To open this discussion, we highlight two areas of SEM research strongly influenced by implicit gender bias.

Weight-Related Syndromes

Perhaps better than any other SEM issue, the transition from the Female Athlete Triad Syndrome (FATS) to the Relative Energy Deficiency in Sport Syndrome (RED-S) to the newly proposed Male Athlete Triad Syndrome (MATS) demonstrates the power of implicit gender bias. Each has comparable definitions [26]. FATS has been defined as a three-pronged spectrum of conditions affecting physically active females: low-energy availability (EA) with or without eating disorders, low bone mineral density (BMD), and menstrual dysfunction. RED-S has been defined similarly in that low EA leads to poor menstrual function in female athletes but includes the effect of low EA on male athletes' hypothalamic-pituitary-gonadal hormonal pathway as well as the effects of low EA on broader health consequences (e.g., decreased BMD, immunological deficiencies, cardiovascular problems, etc.) and performance issues (e.g., decreased coordination, muscle strength, and concentration). MATS is still being debated and defined, but proposed definitions focus on negative effects of low EA on hypogonadism/low testosterone and low BMD or increased bone stress injuries in male athletes. Although these syndromes cover the same broad clinical concerns, the implicit gender bias in interpretation of research results led to this health concern being solely attributed to females at first and thus decades-long delays in research, clinical care, and policy efforts addressing low EA in males along with incomplete/inappropriate approaches to addressing this issue in female athletes.

FATS entered the forefront of SEM consciousness in 1993 at the 40th annual meeting of the American College of Sports Medicine (ACSM) and a subsequent *JAMA* publication which noted "While exercise is widely viewed as beneficial to women of all ages, the pressure to succeed in sports by achieving or maintaining an unrealistically low weight through food restriction and exercise may lead some young women to develop an eating disorder, amenorrhea, and osteoporosis" [27]. In 1997, ACSM published a FATS position statement: "Pressure placed on young women to achieve or maintain unrealistically low body weight underlies development of the Triad." It concluded females training for sports where low body weight was emphasized for "activity or appearance" was at greatest risk, and it called on SEM professionals in female sport to learn about FATS and to develop treatment plans [28]. This focus on feminine appearance and potential injury from physical activity for young females parrots the historical marginalization of female access to sport. However, when a manuscript warned FATS placed decades of women's sports progress at risk given "the creation of yet another form of female specific pathology" that could discourage female's sports participation [29], a group of researchers counterclaimed that manuscript promoted

"an unfounded fear" and presented "a totally unjustified anxiety about the thoughtful and responsible efforts of ACSM to protect and improve the health and safety, and thereby to promote the increasing participation, of women and girls in sport" [30].

Not until 2014 did an IOC workgroup introducing "a broader, more comprehensive term for the condition previously known as 'Female Athlete Triad'", coin "'Relative Energy Deficiency in Sport' (RED-S)" to describe the "complexity" of the physiological impairments caused by low EA and acknowledged males were also affected [31]. The IOC workgroup noted while eating disorders were largely responsible, low EA could be caused by training mismanagement (e.g., too rapid reduction in body fat, extreme exercise, etc.) without the psychological overlay of disordered eating. Thus, while low EA in the context of FATS was traditionally blamed on disordered eating due to females' perceived body image, now that RED-S covered males and females, the conclusion that low EA was most frequent when "leanness and/or weight are important due to their role in performance, appearance or requirement to meet a competition weight category" acknowledged a broader range of contributing factors, including performance goals. This IOC statement recommended a RED-S risk assessment model, return to play guidelines, and recommendations for policy makers to improve male and female athletes' health and well-being.

The 2014 IOC statement did not present any novel research findings. The available research findings regarding the potential physiologic and psychologic effects of low EA were accurate. However, the misinterpretation of these findings resulted in the belief that effects of low EA were uniquely female attributes. This in combination with the labeling of this EA as the Female Athlete Triad Syndrome led to the biased belief that only females were affected. Thus for decades, males with the clinical syndrome associated with low EA were not properly diagnosed and treated, while affected females were stigmatized. Although no one likely intended harm, the undeniable implicit gender bias associated with the interpretation of findings affected the progress of the SEM response to the serious effects of low EA in athletes of both sexes.

ACL Injury Concern

The history of SEM research on, clinical management of, and prevention efforts regarding anterior cruciate ligament (ACL) injuries is another demonstration of the effect of implicit gender bias. ACL injuries have long been portrayed as a young female athlete injury, a perception which may have deprived all athletes from clinical advances. By framing ACL injury as a female athlete issue and focusing research on understanding why females have higher rates of ACL injuries than males in gender comparable sports, by focusing clinical practice guidelines on the care of young female athletes with ACL injury, and by targeting ACL injury prevention efforts at young female athletes, SEM researchers and clinicians missed opportunities to address ACL injuries in both males and females.

Just as the initial naming of the negative health effects of low EA as the *Female* Athlete Triad both reflected and resulted in furthering the effects of implicit gender bias, the history of titling peer-review publications has undoubtedly similarly biased the advancement of ACL research and clinical care. As manuscripts began comparing injury rates in gender comparable sports, some fixated on publications' brief mentions of female athletes having higher rates of lower extremity injuries and knee injuries, even when authors concluded "the respective coupled sports displayed strikingly comparable patterns by sex" and "more dissimilarities in injury patterns were observed between women's sports than between comparable men and women's sports. The results thereby are interpreted that injuries to women athletes are essentially sport-related, not sex-related." [32]. A few examples of the implicit gender bias in titling of peer-reviewed publications driven by those reports of higher injury rates in female athletes include "Knee injuries in female athletes" [33], "Anterior cruciate ligament injuries in the female athlete: Potential risk factors." [34], "The female ACL: Why is it more prone to injury?" [35], "ACL injuries – The gender bias" [36], "Sports-related knee injuries in female athletes: What gives?" [37], and "Why do girls sustain more anterior cruciate ligament injuries than boys?: A review of the changes in estrogen and musculoskeletal structure and function during puberty" [38]. The authors of these papers, published over a 30-year span, nearly universally claimed that understanding gender differences in ACL injury rates would lead to improved clinical management and/or more effective prevention strategies for females. However, despite this focus on why sex differences exist, little progress has been made in reducing the disparity. The higher ACL injury rate in females in gender comparable sports persists in high school and collegiate athletes although injury rates in gender comparable professional sports are similar between men and women [39].

This devotion to determining why ACL injury rates were higher among females in gender comparable sports led to multiple theories regarding extrinsic (e.g., fitness level, jump landing movements, skill level, etc.) and intrinsic (e.g., Q-angle/limb alignment, intercondylar notch dimensions, increased posterior tibial slope, ligament laxity due to hormonal variations, etc.) factors. Echoing the historical notion that sport was too dangerous for women, many of these theories centered on female physical vulnerability to athletics. The numerous studies of such ACL risk factors among females have resulted in multiple reviews/meta-analyses/systematic reviews including papers focused on fitness/strength deficiencies [40, 41], jump landing stabilization [42•], and the effects of sex hormones on ligament laxity [43]. Additionally, an IOC statement reported risk factors for female athletes' non-contact ACL injuries including being in the menstrual cycle's

preovulatory phase and having decreased intercondylar notch width [44]. The focus on menstrual cycle phases as a risk factor for ACL tear due to increased knee laxity became so entrenched that one systematic review suggested "large interventional trials of follicular suppression, including newer hormonal methods" [45] before a subsequent systematic review concluded, "An increased risk of an ACL tear does not appear to be associated with periods of increased laxity" [46•]. Decades of research were spent focused on why females had higher rates of ACL injury rather than focusing on preventing ACL injury in all athletes.

More recent studies of ACL injury prevention programs including training to fatigue [47•], jump landing training [48•], and multi-faceted biomechanical and neuromuscular programs [49] have included both males and females demonstrating the understanding that effective prevention efforts can benefit everyone. Even intrinsic factors once believed to be the very hallmarks of female risk, such as narrowed intercondylar notch dimensions [50, 51•], have now been demonstrated to be risk factors for both females and males. In fact, several researchers have concluded that observed gender differences in the most widely studied ACL injury risk factors likely do not explain the difference in ACL injury rates. For example, one study concluded "changing an athlete's alignment, BMI, or muscle strength may not directly improve his or her movement patterns" [52]. This focus on female ACL injury risks resulted in males being understudied [53]. Because SEM researchers and clinicians focused considerable resources on elucidating the observed higher female ACL injury rates in gender comparable sports, opportunities to develop, implement, and evaluate mechanism-based injury prevention programs that could have benefited both females and males were missed. One recent study that included both females and males concluded that over half of all ACL injuries can be prevented by existing injury prevention programs which meet best-practice recommendations [54•]. Yet little research has explored why more coaches do not adopt such programs.

Another effect of the implicit gender bias within the SEM response to ACL injury is the focus on young females, particularly soccer and basketball players, to the near exclusion of young male football players. Multi-sport studies consistently report that the highest number of ACL injuries occurs in American football due both to the large number of players per team compared to other sports and the relatively high injury rate [55]. A study of injury surveillance data across 20 high school sports found girls had higher knee injury rates than boys in gender comparable sports (RR = 1.52, 95% CI 1.39–1.65), but football (6.29 per 10,000 AE) had a higher knee injury rate than girls' soccer (4.53) (RR = 1.39, 95% CI 1.26–1.53). In fact, football accounted for nearly half of all knee injuries reported in the 20 sports. When considering only ACL injuries, girls again had higher injury rates than boys in gender comparable sports (RR = 2.39, 95% CI 1.91–2.95), but football and girls' soccer tied for the highest ACL injury rate (1.17 per 10,000 AE) [56]. Another study of injury surveillance data across 15 collegiate sports reported that women had higher injury rates than men in soccer and basketball but found football accounted for over 45% of all ACL injuries reported in the 15 sports [57]. Clearly, although knee injuries in girls' sports continued to receive considerable attention because of consistently reported higher injury rates among females in gender comparable sports, the overall burden of knee injuries in football is much greater than the burden in girls' sports. The extensive focus on the need to identify means of protecting young female athletes, while largely ignoring young male football players' ACL injury risk, is indicative of the far-reaching effect that implicit gender bias can play.

Conclusion

Sport is an integral part of American life: it is part of its culture, identity, and physical and mental health. The same can be said for many parts of the world. Sport, however, has long been perceived as a masculine preserve with the benefits of physical activity limited to its male participants. Although women have greater opportunity in the present than previously, the centuries of constructing women's bodies as inferior to men's and thus suggesting they were incapable of competing in sport last through to the present day. SEM has suffered from inherent gender biases, inadvertently contributing medical justifications for envisioning females as frail and in need of protection from vigorous physical activity. Such a position not simply limits female access to sport but also limits the appropriate recognition and treatment of injuries in males because of the presumption that males are too strong to sustain the same injuries females sustain. All athletes deserve better.

This work is a historical review, not a systematic review or a traditional review article attempting to synopsize the entirety of the existing body of knowledge. Thus, the citations provided here definitely do not represent an exhaustive review of any of the topics covered. Rather they are used merely to illustrate points. In addition, we recognize the unfortunate irony inherent in our focus on a cis-gendered discussion of female and male athletes in this historical review of implicit bias in SEM. We fully acknowledge the desperate need to expand the current paucity of knowledge on transgender athletes and non-binary athletes. To paraphrase Bekker et al. [24••] why, in 2020, is SEM and its related disciplines still failing to identify and acknowledge the role that implicit bias plays in the lack of appropriate attention to transgender and non-binary athletes when SEM is, after all, an area that should contain and serve the entire spectrum of researchers, clinicians, policy makers, coaches, and athletes who make up sport.

This historical review of implicit gender bias in SEM intends to drive awareness, support ongoing but still relatively nascent discussion in this space, and to spark an overdue commitment to developing and implementing meaningful and consistent methods to integrate the topic of implicit gender bias into the training curricula of the many professions collaborating in SEM. This work is already underway in other healthcare training fields. Sukhera and Watling have identified key features to integrate an implicit bias training framework into health profession education: (1) create a safe and non-threatening learning context, (2) increase knowledge about the science of implicit bias, (3) emphasize how implicit bias influences behaviors and patient outcomes, (4) increase self-awareness of existing implicit biases, (5) improve conscious efforts to overcome implicit bias, and (6) enhance awareness of how implicit bias influences others [58••]. Such work is a starting point to develop sport specific and consistent educational programs for professionals training to work in SEM.

Compliance with Ethical Standards This review and commentary article did not include any active research on human subjects and thus did not require IRB approval.

Conflict of Interest The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by either of the authors. This is not human subjects research and thus does not require either IRB approval nor application of informed consent.

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