

# EXHIBIT 3



1 D. John Sauer, Mo. Bar No. 58721\*  
2 Justin D. Smith, Mo. Bar No. 63253\*  
3 James Otis Law Group, LLC  
4 13321 North Outer Forty Road, Suite 300  
5 St. Louis, Missouri 63017  
6 Telephone: (314) 562-0031  
7 John.Sauer@james-otis.com

8 *Attorneys for Proposed Intervenor-Defendants President Petersen and Speaker Toma*

9 **IN THE UNITED STATES DISTRICT COURT**  
10 **FOR THE DISTRICT OF ARIZONA**  
11 **TUCSON DIVISION**

12 Jane Doe, *et al.*,

13 Plaintiffs,

14 v.

15  
16  
17  
18  
19 Thomas C. Horne, in his official capacity  
20 as State Superintendent of Public  
21 Instruction, *et al.*,

22 Defendants.  
23  
24  
25  
26  
27  
28

Case No. 4:23-cv-00185-JGZ

**Declaration of Dr. Chad Thomas  
Carlson, M.D., FACSM in Support of  
[Intervenors' Proposed] Opposition to  
Plaintiffs' Motion for a Preliminary  
Injunction**

**TABLE OF CONTENTS**

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28

Introduction ..... 1

Credentials ..... 4

I. OVERVIEW ..... 6

II. A BRIEF HISTORY OF THE RATIONALE FOR SEPARATION OF SPORT BY SEX ..... 8

III. UNDERSTANDING THE CAUSES OF SPORTS INJURIES.. 10

    A. The epidemiological model of injury ..... 11

    B. The biomechanical model of injury ..... 14

IV. THE PHYSICS OF SPORTS INJURY ..... 16

V. GENDER DIFFERENCES RELEVANT TO INJURY ..... 19

    A. Height and weight..... 20

    B. Bone and connective tissue strength ..... 20

    C. Speed ..... 21

    D. Strength/Power ..... 21

    E. Throwing and kicking speed ..... 23

VI. ENHANCED FEMALE VULNERABILITY TO CERTAIN INJURIES 26

    A. Concussions ..... 26

    B. Anterior Cruciate Ligament injuries..... 32

VII. TESTOSTERONE SUPPRESSION WILL NOT PREVENT THE HARM TO FEMALE SAFETY IN ATHLETICS ..... 35

    A. Bone density ..... 39

    B. Size and weight..... 39

    C. Strength..... 40

1	D. Speed .....	43
2	Conclusion.....	44
3	Bibliography .....	48
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		



## Introduction

Up to the present, the great majority of news, debate, and even scholarship about transgender participation in female athletics has focused on sports such as swimming or track and field, and the debate has largely concerned questions of fairness and inclusion. However, the transgender eligibility policies of many high school athletic associations in the United States apply with equal force to all sports, including sports in which players frequently collide with each other, or can be forcefully struck by balls, or equipment such as hockey or lacrosse sticks. And in fact, biologically male transgender athletes have competed in a wide range of high school, collegiate, and professional girls' or women's sports, including, at least, basketball,<sup>1</sup> soccer,<sup>2</sup> volleyball,<sup>3</sup> softball,<sup>4</sup> lacrosse,<sup>5</sup> and even women's tackle football.<sup>6</sup>

The science of sex-specific differences in physiology, intersecting with the physics of sports injury, leaves little doubt that participation by biological males in these types of girls' or women's sports, based on gender identity, creates significant additional risk of injury for the biologically female participants competing alongside these transgender athletes.

---

<sup>1</sup>[https://www.espn.com/espnw/athletes-life/story/\\_/id/10170842/espnw-gabrielle-ludwig-52-year-old-transgender-women-college-basketball-player-enjoying-best-year-life](https://www.espn.com/espnw/athletes-life/story/_/id/10170842/espnw-gabrielle-ludwig-52-year-old-transgender-women-college-basketball-player-enjoying-best-year-life) (accessed 2/17/22)

<sup>2</sup>[https://www.unionleader.com/news/education/nh-bill-limits-women-s-sports-to-girls-born-female/article\\_d1998ea1-a1b9-5ba4-a48d-51a2aa01b910.html](https://www.unionleader.com/news/education/nh-bill-limits-women-s-sports-to-girls-born-female/article_d1998ea1-a1b9-5ba4-a48d-51a2aa01b910.html) (accessed 5/24/22); <https://www.outsports.com/2020/1/17/21069390/womens-soccer-mara-gomez-transgender-player-argentina-primera-division-villa-san-marcos> (accessed 6/20/21)

<sup>3</sup><https://news.ucsc.edu/2016/09/challenging-assumptions.html> (accessed 6/20/21); <https://www.outsports.com/2017/3/20/14987924/trans-athlete-volleyball-tia-thompson> (accessed 6/20/21)

<sup>4</sup><https://www.foxnews.com/us/californias-transgender-law-allows-male-high-schooler-to-make-girls-softball-team> (accessed 6/20/21)

<sup>5</sup><https://savewomenssports.com/f/emilys-story?blogcategory=Our+Stories> (accessed 6/20/21)

<sup>6</sup><https://www.outsports.com/2017/12/13/16748322/britney-stinson-trans-football-baseball> (accessed 6/20/21); <https://www.mprnews.org/story/2018/12/22/transgender-football-player-prevails-in-lawsuit> (accessed 6/20/21)

1 In 2020, after an extensive review of the scientific literature, consultation with  
2 experts, and modeling of expected injuries, World Rugby published revised rules  
3 governing transgender participation, along with a detailed explanation of how the  
4 new policy was supported by current evidence. World Rugby concluded that “there is  
5 currently no basis with which safety and fairness can be assured to biologically female  
6 rugby players should they encounter contact situations with players whose biological  
7 male advantages persist to a large degree,” and that after puberty, “the lowering of  
8 testosterone removes only a small proportion of the documented biological  
9 differences.” Hence, World Rugby concluded that biological men should not compete  
10 in women’s rugby. (World Rugby Transgender Women Guidelines 2020.) World  
11 Rugby has been criticized by some for its new guidelines, but those criticisms have  
12 often avoided discussions of medical science entirely, or have asserted that modeling  
13 scenarios can overstate true risk. What cannot be denied, however, is that World  
14 Rugby’s approach is evidence-based, and rooted in concern for athlete safety. As a  
15 medical doctor who has spent my career in sports medicine, it is my opinion that  
16 World Rugby’s assessment of the evidence is scientifically sound, and that injury  
17 modeling meaningfully predicts that biologically male transgender athletes do  
18 constitute a safety risk for the biologically female athlete in women’s sports.

19 In a similar vein, in 2021, the UK Sports Councils’ Equality Group released  
20 new guidance for transgender inclusion in organized sports. This guidance was  
21 formulated after extensive conversations with stakeholders, a review of scientific  
22 findings related to transgender athletes in sport through early 2021, and an  
23 assessment of the use by some sport national governing bodies of case-by-case  
24 assessment to determine eligibility. Noteworthy within these stakeholder  
25 consultations was a lack of consensus on any workable solution, as well as concerns  
26 related to athlete safety and “adherence to rules which give sport validity.” The  
27 Literature Review accompanying the guidance document further noted that “[t]here  
28 are significant differences between the sexes which render direct competition

1 between males and females . . . unsafe in sports which allow physical contact and  
2 collisions.” (UK Sports Councils’ Equality Group Literature Review 2021 at 1.) Their  
3 review of the science “made clear that there are retained differences in strength,  
4 stamina and physique between the average woman compared with the average  
5 transgender woman....with or without testosterone suppression.” (UK Sports  
6 Councils’ Equality Group Guidance at 3.) This was also reflected in their ten guiding  
7 principles, stating that physical differences between the sexes will “impact safety  
8 parameters in sports which are combat, collision or contact in nature.” (UK Sports  
9 Councils’ Equality Group Guidance 2021 at 7.) Ultimately, UK Sport concluded that  
10 the full inclusion of transgender athletes in women’s sports “cannot be reconciled  
11 within the current structure of sport,” stating that “the inclusion of transgender  
12 people into female sport cannot be balanced regarding transgender inclusion, fairness  
13 and safety in gender-affected sport where there is meaningful competition . . . due to  
14 retained differences in strength, stamina and physique between the average woman  
15 compared with the average transgender woman..., with or without testosterone  
16 suppression.” (UK Sports Councils’ Equality Group Guidance 2021 at 6.) Finally, UK  
17 Sport affirmed the use of sex categorization in sport, along with age and disability,  
18 as important for the maintenance of safety and fairness. (UK Sports Councils’  
19 Equality Group Guidance 2021 at 7–8.)

20           Unfortunately, apart from World Rugby’s careful review and the recent release  
21 of UK Sports Councils’ guidance, the public discourse is lacking any careful  
22 consideration of the question of safety. As a physician who has spent my career caring  
23 for athletes, I find this silence about safety both surprising and concerning. It is my  
24 hope to equip and motivate sports leagues and policy makers to give adequate  
25 attention to the issue of safety for female athletes when transgender policies are being  
26 considered. I first explain the nature and causes of common sports injuries. I then  
27 review physiological differences between male and female bodies that affect the risk  
28 and severity of injuries to females when biological males compete in the female

1 category, and I explain why testosterone suppression does not eliminate these  
2 heightened risks to females. Finally, I explain certain conclusions about those risks.

3 **Credentials**

4 1. I am a medical doctor practicing Sports Medicine, maintaining an active  
5 clinical practice at Stadia Sports Medicine in West Des Moines, Iowa. I received my  
6 M.D. from the University of Nebraska College of Medicine in 1994 and completed a  
7 residency in family medicine at the University of Michigan in 1997.

8 2. Following my time in Ann Arbor, I matched to a fellowship in Sports  
9 Medicine at Ball Memorial Hospital in Muncie, Indiana, training from 1997 to 1999,  
10 with clinical time split between Central Indiana Orthopedics, the Ball State Human  
11 Performance Laboratory, and the Ball State University training room. I received my  
12 board certification in Sports Medicine in 1999, which I continue to hold. Since  
13 residency training, my practice has focused on Sports Medicine—the treatment and  
14 prevention of injuries related to sport and physical activity.

15 3. Since 1997, I have served in several clinical practices and settings as a  
16 treating physician, including time as team physician for both the University of Illinois  
17 and Ball State University, where I provided care to athletes in several sports,  
18 including football, ice hockey, basketball, field hockey, softball, gymnastics, soccer,  
19 and volleyball. In the course of my career, I have provided coverage for NCAA Power  
20 Five Conference championships and NCAA National Championship events in  
21 basketball, field hockey and gymnastics, among other sports, as well as provided  
22 coverage for national championship events for U.S.A. gymnastics, and U.S.  
23 Swimming and Diving. I have also covered professional soccer in Des Moines.

24 4. Since 2006, I have been the physician owner of Stadia Sports Medicine  
25 in West Des Moines, Iowa. My practice focuses on treatment of sports and activity-  
26 related injury, including concussive injury, as well as problems related to the  
27 physiology of sport.

28

1           5.     I have served in and provided leadership for several professional  
2 organizations over the course of my career. In 2004, I was designated a Fellow of the  
3 American College of Sports Medicine (ACSM). I have served on ACSM's Health and  
4 Science Policy Committee since 2010, and for a time chaired their Clinical Medicine  
5 Subcommittee. From 2009 to 2013, I served two elected terms on the Board of  
6 Directors of the American Medical Society for Sports Medicine (AMSSM), and during  
7 that time served as Chair of that body's Practice and Policy Committee. I was  
8 subsequently elected to a four-year term on AMSSM's executive committee in 2017,  
9 and from 2019–20, I served as AMSSM's President. AMSSM is the largest  
10 organization of sports medicine physicians in the world. I gained fellowship status  
11 through AMSSM in 2020—my first year of eligibility. My work for ACSM and  
12 AMSSM has brought with it extensive experience in public policy as relates to Sports  
13 Medicine.

14           6.     In 2020, I was named as AMSSM's first board delegate to the newly-  
15 constituted Physical Activity Alliance. I served as a named member of an NCAA  
16 advisory group on COVID-19, through which I provided input regarding the  
17 cancellation of the basketball tournament in 2020. I also serve as a member of the  
18 Iowa Medical Society's Sports Medicine Subcommittee and have been asked to serve  
19 on the Iowa High School Athletic Association's newly-forming Sports Medicine  
20 Advisory Committee.

21           7.     I have served as a manuscript reviewer for organizational policy  
22 pronouncements, and for several professional publications, most recently a sports  
23 medicine board review book just published in 2023. I have published several articles  
24 on topics related to musculoskeletal injuries in sports and rehabilitation, which have  
25 been published in peer-reviewed journals such as Clinical Journal of Sports Medicine,  
26 British Journal of Sports Medicine, Current Reviews in Musculoskeletal Medicine,  
27 Athletic Therapy Today, and the Journal of Athletic Training. In conjunction with my  
28 work in policy advocacy, I have helped write several pieces of legislation, including

1 the initial draft of what became the Sports Medicine Licensure Clarity Act, signed  
2 into law by President Trump in 2018, which eases the restrictions on certain  
3 practitioners to provide health services to athletes and athletic teams outside of the  
4 practitioner’s home state. A list of my publications over the past ten (10) years is  
5 included as an appendix to this report.

6 8. In the past four years, I testified as an expert witness by deposition in  
7 *B.P.J. v. West Virginia*, S.D. W.V., No. 2:21-cv-00316 and *LE. v. Lee*, No. 3:21-cv-  
8 00835.

9 9. I am being compensated for my services as an expert witness in this case  
10 at the rates of \$650 per hour for consultation, \$800 per hour for deposition or trial  
11 testimony.

12 **I. OVERVIEW**

13 10. In this statement, I offer information and my own professional opinion  
14 on the potential for increased injury risk to females in sports when they compete  
15 against biologically male transgender athletes.<sup>7</sup> At many points in this statement, I  
16 provide citations to published, peer-reviewed articles that provide relevant and  
17 supporting information to the points I make.

18 11. The principal conclusions that I set out in this white paper are as  
19 follows:

- 20 a. Government and sporting organizations have historically considered  
21 the preservation of athlete safety as one component of competitive  
22 equity.

---

23  
24 <sup>7</sup> In the body of this paper, I use the terms “male” and “female” according to their ordinary  
25 medical meaning—that is to say, to refer to the two biological sexes. I also use the word  
26 “man” to refer to a biologically male human, and “woman” to refer to a biologically female  
27 human. In the context of this opinion, I include in these categories non-syndromic,  
28 biologically-normal males and females who identify as a member of the opposite sex,  
including those who use endogenous hormone suppression to alter their body habitus. In  
contexts that are not focused on questions of biology and physiology, terms of gender are  
sometimes used to refer to subjective identities rather than to biological categories—  
something I avoid for purposes of a paper focused on sports science.



1           b. Injury in sport is somewhat predictable based on modeling  
2           assumptions that take into account relevant internal and external risk  
3           factors.

4           c. Males exhibit large average advantages in size, weight, and physical  
5           capacity over females—often falling far outside female ranges. Even  
6           before puberty, males demonstrate a performance advantage over  
7           females in most athletic endeavors. Failure to preserve protected  
8           female-only categories in contact sports (broadly defined) will ultimately  
9           increase both the frequency and severity of injury suffered by female  
10          athletes who share playing space with these males.

11          d. Current research supports the conclusion that suppression of  
12          testosterone levels by males who have already begun puberty will not  
13          fully reverse the effects of testosterone on skeletal size, strength, or  
14          muscle hypertrophy, leading to persistence of sex-based differences in  
15          power, speed, and force-generating capacity.

16          12. In this white paper, I use the term “contact sports” to refer broadly to  
17          all sports in which collisions between players, or collisions between equipment such  
18          as a stick or ball and the body of a player, occur with some frequency (whether or not  
19          permitted by the rules of the game), and are well recognized in the field of sports  
20          medicine as causes of sport-related injuries.<sup>8</sup> The 1975 Title IX implementing  
21          regulations (34 CFR § 106.41) say that “for purposes of this [regulation] contact sports  
22          include boxing, wrestling, rugby, ice hockey, football, basketball, *and other sports* the  
23          purpose or major activity of which involves bodily contact.” Certainly, all of the sports  
24          specifically named in the regulation fall within my definition of “contact sport.”  
25          Mixed martial arts, field hockey (Barboza 2018), soccer (Kuczinski 2018), rugby

---

26  
27          <sup>8</sup> It is common to see, within the medical literature, reference to distinctions between  
28          “contact” and “collision” sports. For purposes of clarity, I have combined these terms, since  
in the context of injury risk modeling, there is no practical distinction between them.

1 (Viviers 2018), lacrosse (Pierpoint 2019), volleyball,<sup>9</sup> baseball, and softball also  
2 involve collisions that can and do result in injuries, and so also fall within my  
3 definition.

4 **II. A BRIEF HISTORY OF THE RATIONALE FOR SEPARATION OF**  
5 **SPORT BY SEX**

6 13. World Rugby is correct when it notes that “the women’s category exists  
7 to ensure protection, safety, and equality” for women. (World Rugby Transgender  
8 Women Guidelines 2020.) To some extent, those in charge of sport governing bodies  
9 in the modern era have always recognized the importance of grouping athletes  
10 together based on physical attributes, in order to ensure both safety and competitive  
11 balance. Weight classifications have existed in wrestling since it reappeared as an  
12 Olympic event in 1904. Women and men have participated in separate categories  
13 since the advent of intercollegiate sporting clubs early in the 20<sup>th</sup> century. When Title  
14 IX went into effect in 1975, there were just under 300,000 female high school athletes,  
15 and fewer than 10,000 female collegiate athletes. With the changes that resulted from  
16 Title IX, it was assumed that newly available funds for women in sport would ensure  
17 the maintenance of existing, or creation of new, sex-segregated athletic teams that  
18 would foster greater participation by women. This has been borne out subsequently;  
19 by the first half of the 1980’s these numbers had risen to 1.9 million and nearly  
20 100,000 respectively. (Hult 1989)

21 14. The rationale for ongoing “separate but equal” status when it came to  
22 sex-segregated sports was made clear within the language of the original  
23 implementing regulations of Title IX, which, acknowledging real, biologically-driven  
24 differences between the sexes, created carve-out exceptions authorizing sex-  
25 separation of sport for reasons rooted in the maintenance of competitive equity.

26 \_\_\_\_\_  
27 <sup>9</sup> See [https://www.latimes.com/sports/story/2020-12-08/stanford-volleyball-hayley-](https://www.latimes.com/sports/story/2020-12-08/stanford-volleyball-hayley-hodson-concussions-cte-lawsuit)  
28 [hodson-concussions-cte-lawsuit](https://volleyballmag.com/corinneatchison/), and <https://volleyballmag.com/corinneatchison/> (both  
accessed 6/20/21).



1 Importantly, the effect of these innate sex-based differences on the health and safety  
2 of the athlete were acknowledged by the express authorization of sex-separated teams  
3 for sports with higher perceived injury risk—i.e., “contact sports.” (Coleman 2020.)

4 15. In the almost half century since those regulations were adopted, the  
5 persistent reality of sex-determined differences in athletic performance and safety  
6 has been recognized by the ongoing and nearly universal segregation of men’s and  
7 women’s teams—even those that are not classically defined as being part of a contact  
8 or collision sport.

9 16. Now, however, many schools and sports leagues in this country are  
10 permitting males to compete in female athletics—including in contact sports—based  
11 on gender identity. In my view, these policies have been adopted without careful  
12 analysis of safety implications. Other researchers and clinicians have addressed  
13 questions of the negative impact of such policies on fairness, or equality of athletic  
14 experiences for girls and women, in published articles, and in court submissions. One  
15 recent review of track and field performances, including sprints, distance races and  
16 field events, noted that men surpass the top female performance in each category  
17 between 1000 and 10,000 times *each year*, with hundreds or thousands of men beating  
18 the top women in each event. (Coleman & Shreve.) Although this was not their  
19 primary focus, World Rugby well-summarized the point when it observed that in a  
20 ranking list of the top thousand performances in most sports, every year, *every one*  
21 will have been achieved by a biological male. (World Rugby Transgender Women  
22 Guidelines 2020.) Although most easily documented in athletes who have gone  
23 through puberty, these differences are not exclusively limited to post-pubescent  
24 athletes either. Thus, some national sport governing bodies have tightened their  
25 policies recently to restrict some transgender athletes who began transition at eleven  
26 or twelve years of age from competing in future sanctioned events in their identified  
27 gender. (McLarnon 2023)

28

1           17. Global population-based fitness testing over wide geographical regions  
2 reveals consistent measurable performance advantages of boys over girls in tests  
3 measuring speed, upper and lower body limb strength and power. (Kasovic 2021; De  
4 Miguel-Etayo 2014; Tambalis 2016; Catley 2013.) Prospective data involving the  
5 training of eight-year-old boys and girls in kicking and throwing ability shows  
6 consistently higher performance of boys over girls at baseline, and similar gains from  
7 baseline in both sexes after coaching. (Dohrmann 1964.) I have reviewed the expert  
8 declaration of Gregory A. Brown, Ph.D., FACM of February 23, 2022, provided in West  
9 Virginia's case, which includes evidence from a wide variety of sources, including  
10 population-based mass testing data, as well as age-stratified competition results, all  
11 of which support the idea that prepubertal males run faster, jump higher and farther,  
12 exhibit higher aerobic power output, and have greater upper body strength (evidenced  
13 by stronger hand grip and better performance with chin-ups or bent arm hang) than  
14 comparably aged females. This performance gap is well-documented in population-  
15 based physiologic testing data that exists in databases such as the Presidential  
16 Fitness Test, the Eurofit Fitness test, and additional mass testing data from the UK  
17 and Australia. Collectively, this data reveals that pre-pubertal males outperform  
18 comparably aged females in a wide array of athletic tests including but not limited to  
19 the countermovement jump test, drop jump test, change of direction test, long jump,  
20 timed sit-up test, the 10 X 5 meter shuttle run test, the 20 meter shuttle run test, curl-  
21 ups, pull-ups, push-ups, one mile run, standing broad jump, and bent arm hang test.  
22 Dr. Brown further references studies showing a significant difference in the body  
23 composition of males and females before puberty. In sum, a large and unbridgeable  
24 performance gap between the sexes is well-studied and equally well-documented,  
25 beginning in many cases before puberty. In this white paper, I focus on some of these  
26 differences as they touch on the question of athlete safety.

### 27 **III. UNDERSTANDING THE CAUSES OF SPORTS INJURIES**

28

1           18. The causes for injury in sport are multifactorial. In recent decades,  
2 medical researchers have provided us an evolving understanding of how sports  
3 injuries occur, as well as the factors that make them more or less probable, and more  
4 or less severe. Broadly speaking, there are two ways of modeling injury: the  
5 epidemiological model, and the biomechanical model. These models are not mutually  
6 exclusive, but provide complementary conceptual frameworks to help us stratify risk  
7 in sport.

8 **A. The epidemiological model of injury**

9           19. From a practical standpoint, sports medicine researchers and clinicians  
10 often use the “epidemiological model” to explain, prevent and manage sports injuries.  
11 Broadly speaking, this model views an injury in sport as the product of internal and  
12 external risk factors, triggered by an inciting event. In other words, a given injury is  
13 “caused” by a number of different factors that are unique to a given situation.  
14 (Meeuwse 1994.) When the interplay of these factors exceeds the injury threshold,  
15 injury occurs. One example of how this interplay might work would be a female  
16 distance runner in track who develops a tibial stress fracture, with identified risks of  
17 low estrogen state from amenorrhea (suppression of menses), an aggressive winter  
18 training program on an indoor tile surface, and shoes that have been used for too  
19 many miles, and are no longer providing proper shock absorption. Most risk factors  
20 ebb and flow, with the overall injury risk at any given time fluctuating as well. Proper  
21 attention to risk factor reduction *before* the start of the sports season (including  
22 appropriate rule-making) is the best way to reduce actual injury rates *during* the  
23 season.

24           20. As alluded to, the risk factors associated with injury can be broadly  
25 categorized as internal or external. Internal risk factors are internal to the athlete.  
26 These include relatively fixed variables, such as the athlete’s age, biological sex, bone  
27 mineral density (which affects bone strength) and joint laxity, as well as more  
28

1 mutable variables such as body weight, fitness level, hydration state, current illness,  
2 prior injury, or psychosocial factors such as aggression.

3 21. External risk factors are, as the name suggests, external to the athlete.  
4 These include non-human risks such as the condition of the playing surface or  
5 equipment, athletic shoe wear, or environmental conditions. Other external risk  
6 factors come from opposing competitors, and include such variables as player size,  
7 speed, aggressiveness, and overall adherence to the rules of the game. As already  
8 mentioned, these risks can be minimized through the proper creation and  
9 enforcement of rules, as well as the appropriate grouping of athletes together for  
10 purposes of competition. To the latter point, children don't play contact sports with  
11 adults and, in the great majority of cases, men and women compete in categories  
12 specific to their own biological sex. Certainly these categorical separations are  
13 motivated in part by average performance differences and considerations of fairness  
14 and opportunity. But they are also motivated by safety concerns. When properly  
15 applied, these divisions enhance safety because, when it comes to physical traits such  
16 as body size, weight, speed, muscle girth, and bone strength, although a certain  
17 amount of variability exists within each group, the averages and medians differ  
18 widely *between* the separated groups.<sup>10</sup>

19 22. Thus, each of these commonly utilized groupings of athletes represents  
20 a pool of individuals with predictable commonalities. Epidemiological risk  
21 assessment is somewhat predictable and translatable as long as these pools remain  
22 intact. But the introduction of outside individuals into a given pool (e.g. an adult onto  
23

---

24 <sup>10</sup> In some cases, safety requires even further division or exclusion. A welterweight boxer  
25 would not compete against a heavyweight, nor a heavyweight wrestle against a smaller  
26 athlete. In the case of youth sports, when children are at an age where growth rates can  
27 vary widely, leagues will accommodate for naturally-occurring large discrepancies in body  
28 size by limiting larger athletes from playing positions where their size and strength is likely  
to result in injury to smaller players. Thus, in youth football, players exceeding a certain  
weight threshold may be temporarily restricted to playing on the line and disallowed from  
carrying the ball, or playing in the defensive secondary, where they could impose high-  
velocity hits on smaller players.

1 a youth football team, or males into most women's sports) would change the balance  
2 of risk inside that pool. Simply put, when you introduce larger, faster, and stronger  
3 athletes from one pool into a second pool of athletes who are *categorically* smaller  
4 (whether as a result of age or sex), you have altered the characteristics of the second  
5 pool, and, based on known injury modeling, have statistically increased the injury  
6 risk for the original athletes in that pool. This, in a nutshell, is the basis for World  
7 Rugby's recommendations.

8 23. Most clinical studies of the epidemiology of sports injuries use a  
9 multivariate approach, identifying multiple independent risk factors and examining  
10 how these factors might interact, in order to determine their relative contribution to  
11 injury risk, and make educated inferences about causation. (Meeuwise 1994.)

12 24. In applying the multivariate approach, the goal is to keep as many  
13 variables as possible the same so as to isolate the potential effect of a single variable  
14 (such as age or biological sex) on injury risk, as well as to determine how the isolated  
15 variable interacts with the other analyzed variables to affect injury risk. Failure to  
16 consider relevant independent variables can lead to error. Researchers focusing on  
17 differences between male and female athletes, for example, would not compare  
18 concussion rates of a high school girls' soccer team to concussion rates of a  
19 professional men's soccer team, because differences in the concussion rate might be  
20 due to a number of factors besides sex, such as age, body mass, relative differences in  
21 skill, speed, or power, as well as differences in training volume and intensity.

22 25. As indicated earlier, an injury event is usually the end product of a  
23 number of different risk factors coming together. (Bahr 2005.) A collision between two  
24 soccer players who both attempt to head the ball, for example, might be the inciting  
25 event that causes a concussion. Although the linear and angular forces that occur  
26 through sudden deceleration would be the proximate cause of this injury, the  
27 epidemiological model of injury would also factor in "upstream" risks, predicting the  
28 possibility of an injury outcome for each athlete differently depending on the sum of

1 these risks. If the collision injury described above occurs between two disparately-  
2 sized players, the smaller athlete will tend to decelerate more abruptly than the  
3 larger athlete, increasing the smaller athlete's risk for injury. Additional  
4 discrepancies in factors such as neck strength, running speeds, and muscle force  
5 generation capacity all result in differing risks and thus, the potential for differing  
6 injury outcomes from the same collision. As I discuss later in this white paper, there  
7 are significant statistical differences between the sexes when it comes to each of these  
8 variables, meaning that in a collision sport where skeletally mature males and  
9 females are playing against one another, there is a higher statistical likelihood that  
10 injury will result when collisions occur, and in particular there is a higher likelihood  
11 that a female will suffer injury. This again is the basis for the recent decision by  
12 World Rugby to disallow the crossover of men into women's rugby, regardless of  
13 gender identity. (World Rugby Transgender Women Guidelines 2020.) The decision-  
14 making represented by this policy change is rational and rooted in objective facts and  
15 objective risks of harm, because it takes real, acknowledged, and documented  
16 physical differences between the sexes (in many cases before adolescence), and  
17 models expected injury risk on the basis of the known differences that persist even  
18 after hormone manipulation.

19 **B. The biomechanical model of injury**

20 26. Sports medicine researchers and clinicians also consider a  
21 biomechanical approach when it comes to understanding sports injuries. In the  
22 biomechanical model of injury, injury is considered to be analogous to the failure of a  
23 machine or other structure. Every bone, muscle, or connective tissue structure in an  
24 athlete's body has a certain load tolerance. Conceptually, when an external "load"  
25 exceeds the load tolerance of a given structure in the human body, an injury occurs.  
26 (Fung 1993 at 1.) Thus, researchers focus on the mechanical load—the force exerted  
27 on a bone, ligament, joint or other body part—and the load tolerance of that impacted  
28 or stressed body part, to understand what the typical threshold for injury is, and how



1 predictable this might be. (McIntosh 2005 at 2–3.) Biomechanical models of injury  
2 usually consider forces in isolation. The more consistent the movement pattern of an  
3 individual, and the fewer the contributions of unexpected outside forces to the athlete,  
4 the more accurate biomechanical predictions of injury will be.

5       27. Biomechanical modeling can be highly predictive in relatively simple  
6 settings. For example, in blunt trauma injury from falls, mortality predictably rises  
7 the greater the fall. About 50% of people who fall four stories will survive, while only  
8 10% will survive a fall of seven stories. (Buckman 1991.) As complexity increases,  
9 predictability in turn decreases. In sport, the pitching motion is highly reproducible,  
10 and strain injury to the ulnar collateral ligament (UCL) of the elbow can be modeled.  
11 The load tolerance of the UCL of a pitcher’s elbow is about 32 Newton-meters, but the  
12 failure threshold of a ligament like this in isolation is not the only determinant of  
13 whether injury will occur. During the pitching motion, the valgus force imparted to  
14 the elbow (gapping stress across the inner elbow that stretches the UCL) routinely  
15 reaches 64 Newtons, which is obviously greater than the failure threshold of the  
16 ligament. Since not all pitchers tear their UCLs, other variables innate to an athlete  
17 must mitigate force transmission to the ligament and reduce risk. The load tolerance  
18 of any particular part of an athlete’s body is thus determined by other internal factors  
19 such as joint stiffness, total ligament support, muscle strength across the joint, or  
20 bone mineral density. Injury load can be self-generated, as in the case of a pitcher’s  
21 elbow, or externally-generated, as in the case of a linebacker hitting a wide receiver.  
22 While load tolerance will vary by individual, as described above, and is often reliant  
23 on characteristics innate to a given athlete, external load is determined by outside  
24 factors such as the nature of the playing surface or equipment used, in combination  
25 with the weight and speed of other players or objects (such as a batted ball) with  
26 which the player collides. (Bahr 2005.)

27       28. As this suggests, the two “models” of sports injuries described above are  
28 not in any sense inconsistent or in tension with each other. Instead, they are

1 complementary ways of thinking about injuries that can provide different insights.  
2 But the important point to make regarding these models is that in either model,  
3 injury risk (or the threshold for injury) rises and falls depending on the size of an  
4 externally-applied force, and the ability of a given athlete to absorb or mitigate that  
5 force.

#### 6 **IV. THE PHYSICS OF SPORTS INJURY**

7 29. Sports injuries often result from collisions between players, or between  
8 a player and a rapidly moving object (e.g. a ball or hockey puck, a lacrosse or hockey  
9 stick). In soccer, for example, most head injuries result from collisions with another  
10 player's head or body, collision with the goal or ground, or from an unanticipated blow  
11 from a kicked ball. (Boden 1998; Mooney 2020.) In basketball, players often collide  
12 with each other during screens, while diving for a loose ball, or while driving to the  
13 basket. In lacrosse or field hockey, player-to-player, or player-to-stick contact is  
14 common.

15 30. But what are the results of those collisions on the human body? Basic  
16 principles of physics can cast light on this question from more than one angle. A  
17 general understanding of these principles can help us identify factors that will  
18 predictably increase the relative risk, frequency, and severity of sports injuries, given  
19 certain assumptions.

20 31. First, we can consider **energy**. Every collision involves an object or  
21 objects that possess energy. The energy embodied in a moving object (whether a  
22 human body, a ball, or anything else) is called kinetic energy.

23 32. Importantly, the kinetic energy of a moving object is expressed as:  
24  $E_k = \frac{1}{2}mv^2$ . That is, kinetic energy is a function of the mass of the object multiplied  
25 by the *square* of its velocity. (Dashnaw 2012.) To illustrate with a simple but extreme  
26 example: if athletes A and B are moving at the same speed, but athlete A is twice as  
27 heavy, athlete A carries twice as much kinetic energy as athlete B. If the two athletes  
28 weigh the same amount, but athlete A is going twice as fast, athlete A carries four



1 times as much kinetic energy as athlete B. But as I have noted, the kinetic energy of  
 2 a moving object is a function of the mass of the object multiplied by the square of its  
 3 velocity. Thus, if athlete A is twice as heavy, and moving twice as fast, athlete A will  
 4 carry eight times the kinetic energy of athlete B into a collision.<sup>11</sup>

5 33. The implication of this equation means that what appear to be relatively  
 6 minor discrepancies in size and speed can result in major differences in energy  
 7 imparted in a collision, to the point that more frequent and more severe injuries can  
 8 occur. To use figures that correspond more closely to average differences between men  
 9 and women, if Player M weighs only 20% more than Player F, and runs only 15%  
 10 faster, Player M will bring *58% more kinetic energy* into a collision than Player F.<sup>12</sup>

11 34. The law of conservation of energy tells us that energy is never destroyed  
 12 or “used up.” If kinetic energy is “lost” by one body in a collision, it is inevitably  
 13 transferred to another body, or into a different form. In the case of collision between  
 14 players, or between (e.g.) a ball and a player’s head, some of the energy “lost” by one  
 15 player, or by the ball, may be transformed into (harmless) sound; some may result in  
 16 an increase in the kinetic energy of the player who is struck (through acceleration,  
 17 which I discuss below); but some of it may result in *deformation* of the player’s body—  
 18 which, depending on its severity, may result in injury. Thus, the greater the kinetic  
 19 energy brought into a collision, the greater the potential for injury, all other things  
 20 being equal.

21 35. Alternately, we can consider force and *acceleration*, which is particularly  
 22 relevant to concussion injuries.

23 36. Newton’s third law of motion tells us that when two players collide, their  
 24 bodies experience equal and opposite forces at the point of impact.

---

27 <sup>11</sup>  $2 \times 2^2 = 8$

28 <sup>12</sup>  $1.2 \times (1.15)^2 = 1.587$

1           37. Acceleration refers to the rate of change in speed (or velocity). When two  
2 athletes collide, their bodies necessarily accelerate (or decelerate) rapidly: stopping  
3 abruptly, bouncing back, or being deflected in a different direction. Newton’s second  
4 law of motion tells us that:  $F = ma$  (that is, force equals mass multiplied by  
5 acceleration). From this equation we see that when a larger and a smaller body  
6 collide, and (necessarily) experience equal and opposite forces, the smaller body (or  
7 smaller player, in sport) will experience more rapid acceleration. We observe this  
8 physical principle in action when we watch a bowling ball strike bowling pins: the  
9 heavy bowling ball only slightly changes its course and speed; the lighter pins go  
10 flying.

11           38. This same equation also tells us that if a given player’s body or head is  
12 hit with a *larger* force (e.g., from a ball that has been thrown or hit faster), it will  
13 experience *greater* acceleration, everything else being equal.

14           39. Of course, sport is by definition somewhat chaotic, and forces are often  
15 not purely linear. Many collisions also involve angular velocities, with the production  
16 of rotational force, or torque. Torque can be thought of as force that causes rotation  
17 around a central point. A different but similar equation of Newtonian physics governs  
18 the principles involved.<sup>13</sup> Torque is relevant to injury in several ways. When torque  
19 is applied through joints in directions those joints are not able to accommodate, injury  
20 can occur. In addition, rotational force can cause different parts of the body to  
21 accelerate at different rates—in some cases, very rapid rates, also leading to injury.  
22 For example, a collision where the body is impacted at the waist can result in high  
23 torque and acceleration on the neck and head.

24           40. Sport-related concussion—a common sports injury and one with  
25 potentially significant effects—is attributable to linear, angular, or rotational

---

26  
27 <sup>13</sup> In this equation,  $\tau = I\alpha$ , torque equals moment of inertia multiplied by angular  
28 acceleration, where “moment of inertia” is defined as  $I = mr^2$ , that is, mass multiplied by  
the square of the distance to the rotational axis.

1 acceleration and deceleration forces that result from impact to the head, or from an  
2 impact to the body that results in a whiplash “snap” of the head. (Rowson 2016.) In  
3 the case of a concussive head injury, it is the brain that accelerates or decelerates on  
4 impact, colliding with the inner surface of the skull. (Barth 2001 at 255.)

5 41. None of this is mysterious: each of us, if we had to choose between being  
6 hit either by a large, heavy athlete running at full speed, or by a small, lighter athlete,  
7 would intuitively choose collision with the small, light athlete as the lesser of the two  
8 evils. And we would be right. One author referred to the “increase in kinetic energy,  
9 and therefore imparted forces” resulting from collision with larger, faster players as  
10 “profound.” (Dashnaw 2012.)

## 11 **V. GENDER DIFFERENCES RELEVANT TO INJURY**

12 42. It is important to state up front that it is self-evident to most people  
13 familiar with sport and sport injuries that if men and women were to consistently  
14 participate together in competitive contact sports, there would be higher rates of  
15 injury in women. This is one reason that rule modifications often exist in leagues  
16 where co-ed participation occurs.<sup>14</sup> Understanding the physics of sports injuries helps  
17 provide a theoretical framework for why this is true, but so does common sense and  
18 experience. All of us are familiar with basic objective physiological differences  
19 between the sexes, some of which exist in childhood, and some of which become  
20 apparent after the onset of puberty, and persist throughout adulthood. And as a  
21 result of personal experience, all of us also have some intuitive sense of what types of  
22 collisions are likely to cause pain or injury. Not surprisingly, our “common sense” on  
23 these basic facts about the human condition is also consistent with the observations  
24 of medical science. Below, I provide quantifications of some of these well-known

---

25  
26 <sup>14</sup> For example, see [https://www.athleticbusiness.com/college/intramural-coed-basketball-](https://www.athleticbusiness.com/college/intramural-coed-basketball-playing-rules-vary-greatly.html)  
27 [playing-rules-vary-greatly.html](https://www.athleticbusiness.com/college/intramural-coed-basketball-playing-rules-vary-greatly.html) (detailing variety of rule modifications applied in co-ed  
28 basketball). Similarly, coed soccer leagues often prohibit so-called “slide tackles,” which  
are not prohibited in either men’s or women’s soccer. See, e.g.,  
<http://www.premiercoedsports.com/pages/rulesandpolicies/soccer>.

1 differences between the sexes that are relevant to injury risk, as well as some  
2 categorical differences that may be less well known.

3 **A. Height and weight**

4 43. It is an inescapable fact of the human species that males as a group are  
5 statistically larger and heavier than females. On average, men are 7% to 8% taller  
6 than women. (Handelsman 2018 at 818.) According to the most recently available  
7 Centers for Disease Control and Prevention (CDC) statistics, the weight of the  
8 average U.S. adult male is 16% greater than that of the average U.S. adult female.  
9 (CDC 2018.) This disparity persists into the athletic cohort. Researchers find that  
10 while athletes tend on average to be lighter than non-athletes, the weight difference  
11 between the average adult male and female athlete remains within the same range—  
12 between 14% and 23%, depending on the sport analyzed. (Santos 2014; Fields 2018.)  
13 Indeed, World Rugby estimates that the typical male rugby player weighs 20% to  
14 40% more than the typical female rugby player. (World Rugby Transgender Women  
15 Guidelines 2020.) This size advantage by itself allows men to bring more force to  
16 bear in a collision.

17 **B. Bone and connective tissue strength**

18 44. Men have bones in their arms, legs, feet, and hands that are both larger  
19 and stronger per unit volume than those of women, due to greater cross-sectional  
20 area, greater bone mineral content, and greater bone density. The advantage in bone  
21 size (cross-sectional area) holds true in both upper and lower extremities, even when  
22 adjusted for lean body mass. (Handelsman 2018 at 818; Nieves 2005 at 530.) Greater  
23 bone size in men is also correlated with stronger tendons that are more adaptable to  
24 training (Magnusson 2007), and an increased ability to withstand the forces produced  
25 by larger muscles (Morris 2020 at 5). Male bones are not merely larger, they are  
26 stronger per unit of volume. Studies of differences in arm and leg bone mineral  
27 density—one component of bone strength—find that male bones are denser, with  
28 measured advantages of between 5% and 14%. (Gilsanz 2011; Nieves 2005.)

1           45. Men also have larger ligaments than women (Lin 2019 at 5), and stiffer  
2 connective tissue (Hilton 2021 at Table 1), providing greater protection against joint  
3 injury.

4 **C. Speed**

5           46. When it comes to acceleration from a static position to a sprint, men are  
6 consistently faster than women. World record sprint performance gaps between the  
7 sexes remain significant at between 7% and 10.5%, with world record times in women  
8 now exhibiting a plateau (no longer rapidly improving with time) similar to the  
9 historical trends seen in men. (Cheuvront 2005.) This performance gap has to do with,  
10 among other factors, increased skeletal stiffness, greater cross-sectional muscle area,  
11 denser muscle fiber composition and greater limb length. (Handelsman 2018.)  
12 Collectively, males, on average, run about 10% faster than females. (Lombardo 2018  
13 at 93.) This becomes important as it pertains to injury risk, because males involved  
14 in sport will often be travelling at faster speeds than their female counterparts in  
15 comparable settings, with resultant faster speed at impact, and thus greater impact  
16 force, in a given collision.

17 **D. Strength/Power**

18           47. In 2014, a male mixed-martial art fighter identifying as female and  
19 fighting under the name Fallon Fox fought a woman named Tamikka Brents, and  
20 caused significant facial injuries in the course of their bout. Speaking about their  
21 fight later, Brents said:

22                   “I’ve fought a lot of women and have never felt the strength  
23                   that I felt in a fight as I did that night. I can’t answer  
24                   whether it’s because she was born a man or not because I’m  
25                   not a doctor. I can only say, I’ve never felt so overpowered

1           ever in my life, and I am an abnormally strong female in  
2           my own right.”<sup>15</sup>

3           48.    So far as I am aware, mixed martial arts is not a collegiate or high school  
4 interscholastic sport. Nevertheless, what Brent experienced in an extreme setting is  
5 true and relevant to safety in all sports that involve contact. In absolute terms, males  
6 as a group are substantially stronger than women.

7           49.    Compared to women, men have “larger and denser muscle mass, and  
8 stiffer connective tissue, with associated capacity to exert greater muscular force  
9 more rapidly and efficiently.” (Hilton 2021 at 201.) Research shows that on average,  
10 during the prime athletic years (ages 18–29) men have, on average, 54% greater total  
11 muscle mass than women (33.7 kg vs. 21.8 kg) including 64% greater muscle mass in  
12 the upper body, and 47% greater in the lower body. (Janssen 2000 at Table 1.) The  
13 cross-sectional area of muscle in women is only 50% to 60% that of men in the upper  
14 arm, and 65% to 70% of that of men in the thigh. This translates to women having  
15 only 50% to 60% of men's upper limb strength and 60% to 80% of men's lower limb  
16 strength. (Handelsman 2018 at 812.) Male weightlifters have been shown to be  
17 approximately 30% stronger than female weightlifters of equivalent stature and  
18 mass. (Hilton 2021 at 203.) But in competitive athletics, since the stature and mass  
19 of the average male exceeds that of the average female, actual differences in strength  
20 between average body types will, on average, exceed this. The longer limb lengths of  
21 males augment strength as well. Statistically, in comparison with women, men also  
22 have lower total body fat, differently distributed, and greater lean muscle mass,  
23 which increases their power-to-weight ratios and upper-to-lower limb strength ratios  
24 as a group. Looking at another common metric of strength, males average 57%  
25 greater grip strength (Bohannon 2019) and 54% greater knee extension torque (Neder  
26 1999). Research shows that sex-based discrepancies in lean muscle mass begin to be

---

27  
28 <sup>15</sup> <https://bjj-world.com/transgender-mma-fighter-fallon-fox-breaks-skull-of-her-female-opponent/>



1 established from infancy, and persist through childhood to adolescence. (Davis 2019;  
2 Kirchengast 2001; Taylor 1997; Taylor 2010; McManus 2011.)

3 50. Using their legs and torso for power generation, men can apply  
4 substantially larger forces with their arms and upper body, enabling them to generate  
5 more ball velocity through overhead motions, as well as to generate more pushing or  
6 punching power. In other words, isolated sex-specific differences in muscle strength  
7 in one region (even differences that in isolation seem small) can, and do combine to  
8 generate even greater sex-specific differences in more complex sport-specific  
9 functions. One study looking at moderately-trained individuals found that males can  
10 generate 162% more punching power than females. (Morris 2020.) Thus, multiple  
11 small advantages aggregate into larger ones.

#### 12 **E. Throwing and kicking speed**

13 51. One result of the combined effects of these sex-determined differences  
14 in skeletal structure is that men are, on average, able to throw objects faster than  
15 women. (Lombardo 2018; Chu 2009; Thomas 1985.) By age seventeen, the *average*  
16 male can throw a ball farther than 99% of seventeen-year-old females—which  
17 necessarily means at a faster initial speed assuming a similar angle of release—  
18 despite the fact that factors such as arm length, muscle mass, and joint stiffness  
19 individually don't come close to exhibiting this degree of sex-defined advantage. One  
20 study of elite male and female baseball pitchers showed that men throw baseballs  
21 35% faster than women—81 miles/hour for men vs. 60 miles/hour for women. The  
22 authors of this study attribute this to a sex-specific difference in the ability to  
23 generate muscle torque and power. (Chu 2009.) A study showing greater throwing  
24 velocity in male versus female handball players attributed it to differences in body  
25 size, including height, muscle mass, and arm length. (Van Den Tillaar 2012.)  
26 Interestingly, significant sex-related difference in throwing ability has been shown to  
27 manifest even before puberty, but the difference increases rapidly during and after  
28 puberty. (Thomas 1985 at 266.) These sex-determined differences in throwing speed

1 are not limited to sports where a ball is thrown. Males have repeatedly been shown  
2 to throw a javelin more than 30% farther than females. (Lombardo 2018 Table 2;  
3 Hilton 2021 at 203.) Even in preadolescent children, differences exist. International  
4 youth records for 5- to 12-year-olds in the javelin show 34–55% greater distance in  
5 males vs. females using a 400g javelin.<sup>16</sup>

6 52. Men also serve and spike volleyballs with higher velocity than women,  
7 with a performance advantage in the range of 29–34%. (Hilton 2021.) Analysis of first  
8 and second tier Belgian national elite male volleyball players shows ball spike speeds  
9 of 63 mph and 56 mph respectively. (Forthomme 2005.) NCAA Division I female  
10 volleyball players—roughly comparable to the second-tier male elite group referenced  
11 above—average a ball spike velocity of approximately 40 mph (18.1 m/s). (Ferris 1995  
12 at Table 2.) Notably, based on the measurements of these studies, male spiking speed  
13 in *lower* elite divisions is almost 40% greater than that of NCAA Division I female  
14 collegiate players. Separate analyses of serving speed between elite men and women  
15 Spanish volleyball players showed that the average power serving speed in men was  
16 54.6 mph (range 45.3–64.6 mph), with maximal speed of 76.4 mph. In women, average  
17 power serving speed was 49 mph (range 41–55.3 mph) with maximal speed of 59 mph.  
18 This translates to an almost 30% advantage in maximal serve velocity in men. (Palao  
19 2014.)

20 53. Recall that kinetic energy is dependent on mass and the square of  
21 velocity. A volleyball (with fixed mass) struck by a male, and traveling an average  
22 35% faster than one struck by a female, will deliver 82% more energy to a head upon  
23 impact.

24 54. The greater leg strength and jumping ability of men confer a further  
25 large advantage in volleyball that is relevant to injury risk. In volleyball, an “attack  
26 jump” is a jump to position a player to spike the ball downward over the net against  
27

---

28 <sup>16</sup> <http://age-records.125mb.com/>.



1 the opposing team. Research on elite national volleyball players found that on  
2 average, males exhibited a 50% greater vertical jump height during an “attack” than  
3 did females. (Sattler 2015.) Similar data looking at countermovement jumps (to block  
4 a shot) in national basketball players reveals a 35% male advantage in jump height.  
5 (Kellis 1999.) In volleyball, this dramatic difference in jump height means that male  
6 players who are competing in female divisions will more often be able to successfully  
7 perform a spike, and this will be all the more true considering that the women’s net  
8 height is seven inches lower than that used in men’s volleyball. Confirming this  
9 inference, research also shows that the successful attack percentage (that is, the  
10 frequency with which the ball is successfully hit over the net into the opponent’s court  
11 in an attempt to score) is so much higher with men than women that someone  
12 analyzing game statistics can consistently identify games played by men as opposed  
13 to women on the basis of this statistic alone. These enhanced and more consistently  
14 successful attacks by men directly correlate to their greater jumping ability and  
15 attack velocity at the net. (Kountouris 2015.)

16 55. The combination of the innate male-female differences cited above,  
17 along with the lower net height in women’s volleyball, means that if a reasonably  
18 athletic male is permitted to compete against women, the participating female  
19 players will likely be exposed to higher ball velocities that are outside the range of  
20 what is typically seen in women’s volleyball. When we recall that ball-to-head impact  
21 is a common cause of concussion among women volleyball players, this fact makes it  
22 clear that participation in girls’ or women’s volleyball by biologically male individuals  
23 will increase concussion injury risk for participating girls or women.

24 56. Male sex-based advantages in leg strength also lead to greater kick  
25 velocity. In comparison with women, men kick balls harder and faster. A study  
26 comparing kicking velocity between university-level male and female soccer players  
27 found that males kick the ball with an average 20% greater velocity than females.  
28 (Sakamoto 2014.) Applying the same principles of physics we have just used above,

1 we see that a soccer ball kicked by a male, travelling an average 20% faster than a  
2 ball kicked by a female, will deliver 44% more energy on head impact. Greater force-  
3 generating capacity will thus increase the risk of an impact injury such as concussion.

#### 4 **VI. ENHANCED FEMALE VULNERABILITY TO CERTAIN INJURIES**

5 57. Above, I have reviewed physiological differences that result in the male  
6 body bringing greater weight, speed, and force to the athletic field or court, and how  
7 these differences can result in a greater risk of injury to females when males compete  
8 against them. It is also true that the female body is more vulnerable than the male  
9 body to certain types of injury even when subject to comparable forces. This risk  
10 appears to extend to the younger age cohorts as well. An analysis of Finnish student  
11 athletes from 1987–1991, analyzing over 600,000 person-years of activity exposures,  
12 found, in students under fifteen years of age, higher rates of injury in girls than boys  
13 in soccer, volleyball, judo and karate. (Kujala 1995.) Another epidemiological study  
14 looking specifically at injury rates in over 14,000 middle schoolers over a 20 year  
15 period showed that “in sex-matched sports, middle school girls were more likely to  
16 sustain *any* injury (RR = 1.15, 95% CI = 1.1, 1.2) or a time-loss injury (RR = 1.09, 95%  
17 CI = 1.0, 1.2) than middle school boys.” In analyzed both-sex sports (i.e., sex-separated  
18 sports that both girls and boys play, like soccer), girls sustained higher injury rates,  
19 and greater rates of time-loss injury. (Beachy 2014.) Another study of over 2000  
20 middle school students at nine schools showed that the injury rate was higher for  
21 girls’ basketball than for football (39.4 v 30.7/1000 AEs), and injury rates for girls’  
22 soccer were nearly double that of boys’ soccer (26.3 v. 14.7/1000 AEs). (Caswell 2017.)  
23 In this regard, I will focus on two areas of heightened female vulnerability to  
24 collision-related injury which have been extensively studied: concussions, and  
25 anterior cruciate ligament injuries.

##### 26 **A. Concussions**

27 58. Females are more likely than males to suffer concussions in comparable  
28 sports, and on average suffer more severe and longer lasting disability once a

1 concussion does occur. (Harmon 2013 at 4; Berz 2015; Blumenfeld 2016; Covassin  
2 2003; Rowson 2016.) Females also seem to be at higher risk for post-concussion  
3 syndrome than males. (Berz 2015; Blumenfeld 2016; Broshek 2005; Colvin 2009;  
4 Covassin 2012; Dick 2009; Marar 2012; Preiss-Farzanegan 2009.)

5 59. The most widely-accepted definition of sport-related concussion comes  
6 from the Consensus Statement on Concussion in Sport (see below).<sup>17</sup> (McCrorry 2018.)  
7 To summarize, concussion is “a traumatically induced transient disturbance of brain  
8 function and involves a complex pathophysiological process” that can manifest in a  
9 variety of ways. (Harmon 2013 at 1.)

10 60. Sport-related concussions have undergone a significant increase in  
11 societal awareness and concurrent injury reporting since the initial passage of the  
12 Zachery Lystedt Concussion Law in Washington State in 2009 (Bompadre 2014), and  
13 the subsequent passage of similar legislation governing return-to-play criteria for  
14 concussed athletes in most other states in the United States. (Nat’l Cnf. of State Leg’s  
15 2018.) Concussion is now widely recognized as a common sport-related injury,  
16 occurring in both male and female athletes. (CDC 2007.) Sport-related concussions

---

17  
18 <sup>17</sup> “Sport related concussion is a traumatic brain injury induced by biomechanical forces.  
19 Several common features that may be utilised in clinically defining the nature of a  
concussive head injury include:

20 SRC may be caused either by a direct blow to the head, face, neck or elsewhere on  
the body with an impulsive force transmitted to the head.

21 SRC typically results in the rapid onset of short-lived impairment of neurological  
22 function that resolves spontaneously. However, in some cases, signs and symptoms evolve  
over a number of minutes to hours.

23 SRC may result in neuropathological changes, but the acute clinical signs and  
24 symptoms largely reflect a functional disturbance rather than a structural injury and, as  
such, no abnormality is seen on standard structural neuroimaging studies.

25 SRC results in a range of clinical signs and symptoms that may or may not involve  
26 loss of consciousness. Resolution of the clinical and cognitive features typically follows a  
sequential course. However, in some cases symptoms may be prolonged.

27 The clinical signs and symptoms cannot be explained by drug, alcohol, or  
28 medication use, other injuries (such as cervical injuries, peripheral vestibular dysfunction,  
etc) or other comorbidities (e.g., psychological factors or coexisting medical conditions).”

1 can result from player-surface contact or player-equipment contact in virtually any  
2 sport. However, sudden impact via a player-to-player collision, with rapid  
3 deceleration and the transmission of linear or rotational forces through the brain, is  
4 also a common cause of concussion injury. (Covassin 2012; Marar 2012; Barth 2001;  
5 Blumenfeld 2016; Boden 1998; Harmon 2013 at 4.)

6 61. A large retrospective study of U.S. high school athletes showed a higher  
7 rate of female concussions in soccer (79% higher), volleyball (0.6 concussions/10,000  
8 exposures, with 485,000 reported exposures, vs. no concussions in the male cohort),  
9 basketball (31% higher), and softball/baseball (320% higher). (Marar 2012.) A  
10 similarly-sized, similarly-designed study comparing concussion rates between NCAA  
11 male and female collegiate athletes showed, overall, a concussion rate among females  
12 40% higher than that of males. Higher rates of injury were seen across individual  
13 sports as well, including ice hockey (10% higher); soccer (54% higher); basketball (40%  
14 higher); and softball/baseball (95% higher). (Covassin 2016.) The observations of  
15 these authors, my own observations from clinical practice, and the acknowledgment  
16 of our own Society's Position Statement (Harmon 2013), all validate the higher  
17 frequency and severity of sport-related concussions in women and girls.

18 62. Most epidemiological studies to date looking at sport-related concussion  
19 in middle schoolers show that more boys than girls are concussed. There are fewer  
20 studies estimating concussion *rate*. This is, in part, because measuring injury rate is  
21 more time and labor-intensive. Researchers at a childrens' hospital, for example,  
22 could analyze the number of children presenting to the emergency department with  
23 sport-related concussion and publish findings of absolute number. However, to study  
24 concussion incidence, athlete exposures also have to be recorded. Generally speaking,  
25 an athlete exposure is a single practice or game where an athlete is exposed to playing  
26 conditions that could reasonably supply the necessary conditions for an injury to  
27 occur. Rates of athletic injury, concussion among them, are then, by convention,  
28 expressed in terms of injury rate per 1000 athletic exposures. More recently, some

1 studies have been published that analyze the rates of concussion in the middle school  
2 population. Looking at the evidence, the conclusion can be made that females  
3 experience increased susceptibility to concussive injuries before puberty. For  
4 example, Ewing-Cobbs, et al. (2018) found elevated post-concussion symptoms in girls  
5 across all age ranges studied, including children between the ages of 4 and 8. Kerr's  
6 2017 study of middle school students showed over three times the rate of female vs  
7 male concussion in students participating in sex-comparable sports [0.18 v. 0.66/1000  
8 A.E.'s]. (Kerr 2017.) This is the first study I am aware of that mimics the trends seen  
9 in adolescent injury epidemiology showing a higher rate of concussion in girls than  
10 boys in comparable sports.

11 63. More recent research looking at the incidence of sport-related  
12 concussions in U.S. middle schoolers between 2015 and 2020, found that the rate of  
13 concussion was higher in middle school athletes than those in high school. In this  
14 study, girls had more than twice the rate of concussion injury (0.49/1000 athletic  
15 exposures vs 0.23/1000 AE) in analyzed sports (baseball/softball, basketball, soccer  
16 and track), as well as statistically greater time loss. (Hacherl 2021 (Journal of  
17 Athletic Training); Hacherl 2021 (Archives of Clinical Neuropsychology).) The  
18 authors hypothesized that the increasing incidence of concussion in middle school  
19 may relate to "other distinct differences associated with the middle school sport  
20 setting itself, such as, the large variations in player size and skill."<sup>18</sup>

21 64. In addition, females on average suffer materially greater cognitive  
22 impairment than males when they do suffer a concussion. Group differences in  
23 cognitive impairment between females and males who have suffered concussion have  
24 been extensively studied. A study of 2340 high school and collegiate athletes who  
25 suffered concussions determined that females had a 170% higher frequency of  
26 cognitive impairment following concussions, and that in comparison with males,

---

27  
28 <sup>18</sup> <https://www.nata.org/press-release/062421/middle-school-sports-have-overall-higher-rate-concussion-reported-high-school>.

1 female athletes had significantly greater declines in simple and complex reaction  
2 times relative to their preseason baseline levels. Moreover, the females experienced  
3 greater objective and subjective adverse effects from concussion even after adjusting  
4 for potentially protective effect of helmets used by some groups of male athletes.  
5 (Broshek 2005 at 856, 861; Colvin 2009; Covassin 2012.)

6 65. This large discrepancy in frequency and severity of concussion injury is  
7 consistent with my own observations across many years of clinical practice. The large  
8 majority of student athletes who have presented at my practice with severe and long-  
9 lasting cognitive disturbance have been adolescent girls. I have seen girls remain  
10 symptomatic for over a year, and lose ground academically and become isolated from  
11 their peer groups due to these ongoing symptoms. For patients who experience these  
12 severe effects, post-concussion syndrome can be life-altering.

13 66. Some of the anatomical and physiological differences that we have  
14 considered between males and females help to explain the documented differences in  
15 concussion rates and in symptoms between males and females. (Covassin 2016; La  
16 Fontaine 2019; Lin 2019; Tierney 2005; Wunderle 2014.) Anatomically, there are  
17 significant sex-based differences in head and neck anatomy, with females exhibiting  
18 in the range of 30% to 40% less head-neck segment mass and neck girth, and 49%  
19 lower neck isometric strength. This means that when a female athlete's head is  
20 subjected to the same load as an analogous male, there will be a greater tendency for  
21 head acceleration, and resultant injury. (Tierney 2005 at 276–277.)

22 67. When modeling the effect of the introduction of male mass, speed, and  
23 strength into women's rugby, World Rugby gave particular attention to the resulting  
24 increases in forces and acceleration (and injury risk) experienced in the head and  
25 neck of female players. Their analysis found that “the magnitude of the known risk  
26 factors for head injury are . . . predicted by the size of the disparity in mass between  
27 players. The addition of [male] speed as a biomechanical variable further increases  
28 these disparities,” and their model showed an increase of up to 50% in neck and head



1 acceleration that would be experienced in a typical tackle scenario in women’s rugby.  
2 As a result, “a number of tackles that currently lie beneath the threshold for injury  
3 would now exceed it, causing head injury.” (World Rugby Transgender Women  
4 Guidelines 2020.) While rugby is notoriously contact-intensive, similar increases to  
5 risk of head and neck injury to women are predictable in any sport context in which  
6 males and females collide at significant speed, as happens from time to time in sports  
7 including soccer, softball, and basketball.

8 68. In addition, even when the heads of female and male athletes are  
9 subjected to identical accelerative forces, there are sex-based differences in neural  
10 anatomy and physiology, cerebrovascular organization, and cellular response to  
11 concussive stimuli that make the female more likely to suffer concussive injury, or  
12 more severe concussive injury. For instance, hypothalamic-pituitary disruption is  
13 thought to play a role in post-concussion symptomatology that differentially impacts  
14 women. (McGroarty 2020; Broshek 2005 at 861.) Another study found that elevated  
15 progesterone levels during one portion of the menstrual cycle were associated with  
16 more severe post-concussion symptomatology that differentially impacted women.  
17 (Wunderle 2014.)

18 69. As it stands, when females compete against each other, they already  
19 have higher rates of concussive injury than males, across most sports. The addition  
20 of biologically male athletes into women’s contact sports will inevitably increase the  
21 risk of concussive injury to girls and women, for the multiple reasons I have explained  
22 above, including, but not limited to, the innate male advantage in speed and lean  
23 muscle mass. Because the effects of concussion can be severe and long-lasting,  
24 particularly for biological females, we can predict with some confidence that if  
25 participation by biological males in women’s contact sports based on gender identity  
26 becomes more common, more biological females will suffer substantial concussive  
27 injury and the potential for long-term harm as a result.

28

1 **B. Anterior Cruciate Ligament injuries**

2 70. The Anterior Cruciate Ligament (“ACL”) is a key knee stabilizer that  
3 prevents anterior translation of the tibia relative to the femur and also provides  
4 rotatory and valgus knee stability.<sup>19</sup> (Lin 2019 at 4.) Girls and women are far more  
5 vulnerable to ACL injuries than are boys and men. The physics of injury that we have  
6 reviewed above makes it inevitable that the introduction of biologically male athletes  
7 into the female category will increase still further the occurrence of ACL injuries  
8 among girls or women who encounter these players on the field.

9 71. Sports-related injury to the ACL is so common that it is easy to overlook  
10 the significance of it. But it is by no means a trivial injury, as it can end sports careers,  
11 require surgery, and usually results in early-onset, post-traumatic osteoarthritis,  
12 triggering long-term pain and mobility problems later in life. (Wang 2020.)

13 72. Even in the historic context in which girls and women limit competition  
14 to (and so only collide with) other girls and women, the rate of ACL injury is  
15 substantially higher among female than male athletes. (Flaxman 2014; Lin 2019;  
16 Agel 2005.) One meta-analysis of 58 studies reports that female athletes have a 150%  
17 relative risk for ACL injury compared with male athletes, with other estimates  
18 suggesting as much as a 300% increased risk. (Montalvo 2019; Sutton 2013.)  
19 Particularly in those sports designated as contact sports, or sports with frequent  
20 cutting and sharp directional changes (basketball, field hockey, lacrosse, soccer),  
21 females are at greater risk of ACL injury. In basketball and soccer, this risk extends  
22 across all skill levels, with female athletes between two and eight times more likely  
23 to sustain an ACL injury than their male counterparts. (Lin 2019 at 5.) These  
24 observations are widely validated, and consistent with the relative frequencies of  
25 ACL injuries that I see in my own practice.

26  
27  
28 <sup>19</sup> Valgus force at the knee is a side-applied force that gaps the medial knee open.



1           73. When the reasons underlying the difference in the incidence of ACL  
2 injury between males and females were first studied in the early 1990s, researchers  
3 speculated that the difference might be attributable to females' relative inexperience  
4 in contact sports, or to their lack of appropriate training. However, a follow-up 2005  
5 study looking at ACL tear disparities reported that, "Despite vast attention to the  
6 discrepancy between anterior cruciate ligament injury rates between men and  
7 women, these differences continue to exist." (Agel 2005 at 524.) Inexperience and lack  
8 of training do not explain the differences. Sex seems to be an independent predictor  
9 of ACL tear risk.

10           74. In fact, as researchers have continued to study this discrepancy, they  
11 have determined that multiple identifiable anatomical and physiological differences  
12 between males and females play significant roles in making females more vulnerable  
13 to ACL injuries than males. (Flaxman 2014; Lin 2019; Wolf 2015.) Summarizing the  
14 findings of a number of separate studies, one researcher recently cited as anatomical  
15 risk factors for ACL injury smaller ligament size, decreased femoral notch width,  
16 increased posterior-inferior slope of the lateral tibia plateau, increased knee and  
17 generalized laxity, and increased body mass index (BMI). With the exception of  
18 increased BMI, each of these factors is more likely to occur in female than male  
19 athletes. (Lin 2019 at 5.) In addition, female athletes often stand in more knee valgus  
20 (that is, in a "knock-kneed" posture) due to wider hips and a medially-oriented femur.  
21 Often, this is also associated with a worsening of knee valgus during jump landings.  
22 The body types and movement patterns associated with these valgus knee postures  
23 are more common in females and increase the risk for ACL tear. (Hewett 2005.)

24           75. As with concussion, the cyclic fluctuation of sex-specific hormones in  
25 women is also thought to be a possible risk factor for ACL injury. Estrogen acts on  
26 ligaments to make them more lax, and it is thought that during the ovulatory phase  
27 of menses (when estrogen levels peak), the risk of ACL tear is higher. (Chidi-Ogbolu  
28 2019 at 1; Herzberg 2017.)

1           76. Whatever the factors that increase the injury risk for ACL tears in  
2 women, the fact that a sex-specific difference in the rate of ACL injury exists is well  
3 established and widely accepted.

4           77. Although non-contact mechanisms are the most common reason for ACL  
5 tears in females, tears related to contact are also common, with ranges reported  
6 across multiple studies of from 20%–36% of all ACL injuries in women. (Kobayashi  
7 2010 at 672.) For example, when a soccer player who is kicking a ball is struck by  
8 another player in the lateral knee of the stance leg, medial and rotational forces can  
9 tear the medial collateral ligament (MCL), the ACL, and the meniscus. Thus, as  
10 participation in the female category based on identity rather than biology becomes  
11 more common (entailing the introduction of athletes with characteristics such as  
12 greater speed and lean muscle mass), and as collision forces suffered by girls and  
13 women across the knee increase accordingly, the risk for orthopedic injury and in  
14 particular ACL tears among impacted girls and women will inevitably rise.

15           78. Of course, there exists variation in all these factors within a given group  
16 of males or females. However, it is also true that within sex-specific pools, size  
17 differential is somewhat predictable and bounded, even considering outliers. When  
18 males are permitted to enter into the pool of female athletes based on gender identity  
19 rather than biological sex, there is an increased possibility that a statistical outlier  
20 in terms of size, weight, speed, and strength—and potentially an extreme outlier—is  
21 now entering the female pool. Although injury is not guaranteed, risks to female  
22 participants will increase. And as I discuss later, the available evidence together  
23 suggests that this will be true even with respect to males who have been on  
24 testosterone suppression for a year or more. World Rugby relied heavily upon this  
25 when they were determining their own policy, and I think it is important to reiterate  
26 that this policy, rooted in concern for athlete safety, is justifiable based upon current  
27 evidence from medical research and what we know about biology.

28

1 **VII. TESTOSTERONE SUPPRESSION WILL NOT PREVENT THE HARM TO**  
2 **FEMALE SAFETY IN ATHLETICS**

3 79. A recent editorial in the New England Journal of Medicine opined that  
4 policies governing transgender participation in female athletics “must safeguard the  
5 rights of all women—whether cisgender or transgender.” (Dolgin 2020.)  
6 Unfortunately, the physics and medical science reviewed above tell us that this is not  
7 practically possible. If biological males are given a “right” to participate in the female  
8 category based on gender identity, then biological women will be denied the right to  
9 reasonable expectations of safety and injury risk that have historically been  
10 guaranteed by ensuring that females compete (and collide) only with other females.

11 80. Advocates of unquestioning inclusion based on gender identity often  
12 contend that hormonal manipulation of a male athlete can feminize the athlete  
13 enough that he is comparable with females for purposes of competition. The NCAA’s  
14 Office of Inclusion asserts (still accessible on the NCAA website as of this writing)  
15 that “It is also important to know that any strength and endurance advantages a  
16 transgender woman arguably may have as a result of her prior testosterone levels  
17 dissipate after about one year of estrogen or testosterone suppression therapy.”<sup>20</sup>  
18 (NCAA 2011 at 8.) Whether or not this is true is a critically important question.

19 81. At the outset, we should note that while advocates sometimes claim that  
20 testosterone suppression *can* eliminate physiological advantages in a biological male,  
21 none of the relevant transgender eligibility policies that I am aware of prior to 2021  
22 requires any demonstration that it has *actually* achieved that effect in a particular  
23 male who seeks admission into the female category. The Connecticut policy that is  
24 currently at issue in ongoing litigation permits admission to the female category at  
25 the high school level without requiring any testosterone suppression at all. Prior to  
26 their new policy, just announced in January 2022, the NCAA’s policy required no

---

27  
28 <sup>20</sup> <https://www.ncaa.org/sports/2016/3/2/lesbian-gay-bisexual-transgender-and-questioning-lgbtq.aspx>

1 demonstration of any reduction of performance capability, change in weight, or  
2 regression of any other physical attribute of the biological male toward female levels.  
3 It did not require achievement of any particular testosterone level, and did not  
4 provide for any monitoring of athletes for compliance. Moving forward, through a  
5 phasing process, the NCAA will ultimately require athletes in each sport to meet  
6 requirements of their sport's national governing body (NGB). If no policy exists, the  
7 policy of that sport's international governing body applies, or, finally, if no policy  
8 exists there, the 2015 policy of the International Olympic Committee (IOC) will apply.  
9 The 2015 IOC policy requires no showing of any diminution of any performance  
10 capability or physical attribute of the biological male, and requires achievement and  
11 compliance monitoring only of a testosterone level below 10nmol/liter—a level far  
12 above levels occurring in normal biological females (0.06 to 1.68 nmol/L).<sup>21</sup> Indeed,  
13 female athletes with polycystic ovarian disorder—a condition that results in elevated  
14 testosterone levels—rarely exceed 4.8 nmol/L, which is the basis for setting the  
15 testing threshold to detect testosterone *doping* in females at 5.0 nmol/L. Thus, males  
16 who qualify under the 2015 IOC policy to compete as transgender women may have  
17 testosterone levels—even after hormone suppression—*double* the level that would  
18 disqualify a biological female for doping with testosterone.<sup>22</sup>

19 82. As Dr. Emma Hilton has observed, the fact that there are over 3000 sex-  
20 specific differences in skeletal muscle alone makes the hypothesis that sex-linked  
21 performance advantages are attributable solely to current circulating testosterone  
22 levels improbable at best. (Hilton 2021 at 200–01.) Indeed, next to breast tissue,  
23

---

24 <sup>21</sup> Normal testosterone range in a healthy male averages between 7.7 and 29.4 nmol/L.

25 <sup>22</sup> In November 2021, the IOC released new guidelines, deferring decision-making about a  
26 given sport's gender-affectedness to its governing body. The current NCAA policy,  
27 however, still utilizes the 2015 IOC policy to determine an athlete's eligibility in event that  
28 the sport's national and international governing bodies lack policies to determine  
eligibility.

1 there is no tissue in the human body with more sex-differentiated genetic expression  
2 than skeletal muscle. (Gershoni 2017)

3 83. Assuming that active treatment with gender-affirming therapies  
4 actually result in full testosterone suppression – the evidence for which is mixed –  
5 (Heather 2022) the available evidence strongly indicates that no amount of  
6 testosterone suppression can eliminate male physiological advantages relevant to  
7 performance and safety. Several authors have recently reviewed the science and  
8 statistics from numerous studies that demonstrate that one year (or more) of  
9 testosterone suppression does not substantially eliminate male performance  
10 advantages. (Hilton 2021; DeVarona 2021; Harper 2021.) As a medical doctor, I will  
11 focus on those specific sex-based characteristics of males who have undergone normal  
12 sex-determined pubertal skeletal growth and maturation that are relevant to the  
13 *safety* of female athletes. Here, too, the available science tells us that testosterone  
14 suppression does not eliminate the increased risk to females or solve the safety  
15 problem.

16 84. The World Rugby organization reached this same determination based  
17 on the currently available science, concluding that male physiological advantages  
18 that “create risks [to female players] appear to be only minimally affected” by  
19 testosterone suppression. (World Rugby Transgender Women Guidelines 2020.)

20 85. Surprisingly, so far as public information reveals, the NCAA’s  
21 Committee on Competitive Safeguards is not monitoring and documenting instances  
22 of transgender participation on women’s teams for purposes of injury reporting. In  
23 practice, the NCAA is conducting an experiment which in theory predicts an  
24 increased frequency and severity of injuries to women in contact sports, while at the  
25 same time failing to collect the relevant data from its experiment.

26 86. In their recent guidelines, UK Sport determined that, “based upon  
27 current evidence, testosterone suppression is unlikely to guarantee fairness between  
28 transgender women and natal females in gender-affected sports.” (UK Sports

1 Councils' Equality Group Guidance 2021 at 7.) They also warned that migration to a  
2 scenario by NGBs where eligibility is determined through case-by-case assessment  
3 "is unlikely to be practical nor verifiable for entry into gender-affected sports," in part  
4 because "many tests related to sports performance are volitional," and incentives on  
5 the part of those tested would align with intentional poor performance. (UK Sports  
6 Councils' Equality Group Guidance 2021 at 8.)

7 87. Despite these concerns, this appears to be exactly the route that the IOC  
8 is taking, as reflected in their Framework on Fairness, Inclusion and Non-  
9 Discrimination on the Basis of Gender Identity, released in November of 2021.<sup>23</sup> In  
10 it, the IOC lists two disparate goals. First, that "where sports organizations elect to  
11 issue eligibility criteria for men's and women's categories for a given competition,  
12 they should do so with a view to . . . [p]roviding confidence that no athlete within a  
13 category has an unfair and disproportionate competitive advantage . . . [and]  
14 preventing a risk to the physical safety of other athletes." (IOC Framework 2021 §  
15 4.1.) At the same time, governing bodies are not to preclude any athlete from  
16 competing until evidence exists based upon "robust and peer-reviewed research that  
17 . . . demonstrates a consistent, unfair, disproportionate competitive advantage in  
18 performance and/or an unpreventable risk to the physical safety of other athletes"—  
19 research moreover that "is largely based on data collected *from a demographic group*  
20 *that is consistent in gender and athletic engagement with the group that the eligibility*  
21 *criteria aim to regulate.*" (IOC Framework 2021 § 6.1) Finally, affected athletes may  
22 appeal any evidence-based decision-making process through a further "appropriate  
23 internal mediation mechanism, such as a Court of Arbitration for Sport." (IOC  
24 Framework 2021 § 6.1.) Rather than cite any of the growing evidence that  
25

---

26 <sup>23</sup> The IOC Framework on Fairness, Inclusion and Non-Discrimination on the Basis of  
27 Gender Identity and Sex Variations is available at  
28 [https://stillmed.olympics.com/media/Documents/News/2021/11/IOC-Framework-Fairness-Inclusion-Non-discrimination-2021.pdf?\\_ga=2.72651665.34591192.1645554375-759350959.1644946978](https://stillmed.olympics.com/media/Documents/News/2021/11/IOC-Framework-Fairness-Inclusion-Non-discrimination-2021.pdf?_ga=2.72651665.34591192.1645554375-759350959.1644946978)



1 testosterone suppression cannot mitigate sex-based performance differences, the  
2 IOC's new policy remains aspirational and opaque, and has come into early criticism  
3 by other Sports Medicine Federations, many of which, such as World Athletics, FINA,  
4 and the International Cyclist Union, have since issued policy changes further  
5 restricting biological males from participating against natal females.<sup>24</sup> (Pigozzi 2022.)  
6 And yet the research relating to hormonal suppression in transgender athletes, as  
7 confirmed by World Rugby and UK Sport, already speaks very clearly to the fact that  
8 males retain a competitive advantage over women that cannot be eliminated through  
9 testosterone suppression alone. What follows is a brief summary of some of these  
10 retained differences as they relate to sport safety.

11 **A. Bone density**

12 88. I start with what is obvious and so far as I am aware undisputed—that  
13 after the male pubertal growth spurt, suppression of testosterone does not materially  
14 *shrink* bones so as to eliminate height, leverage, performance, and weight differences  
15 that follow from simply having longer, larger bones, and being subsequently taller.

16 89. Bone mass (which includes both size and density) is maintained over *at*  
17 *least* two years of testosterone suppression (Singh-Ospina 2017; Fighera 2019), and  
18 one study found it to be preserved even over a median of 12.5 years of suppression  
19 (Hilton 2021; Ruetsche 2005).

20 **B. Size and weight**

21 90. Males are, on average, larger, and heavier. As we have seen, these facts  
22 alone mean that males bring more kinetic energy into collisions, and that lighter  
23

---

24  
25 <sup>24</sup> [World Athletics Council decides on Russia, Belarus and female eligibility | PRESS-](#)  
26 [RELEASES | World Athletics](#)

27 [Transgender athletes | UCI](#)

28 [FINA Restricts Transgender Women From Competing at Elite Level - The New York Times \(nytimes.com\)](#)



1 females will suffer more abrupt deceleration in collisions with larger bodies, creating  
2 heightened injury risk for impacted females.

3 91. Multiple studies have found that testosterone suppression may  
4 modestly reduce, but does not come close to eliminating the male advantage in muscle  
5 mass and lean body mass, which together contribute to the greater average male  
6 weight. Studies looking at the effect of GAHT on lean mass are generally split  
7 between those showing modest decreases, or no statistical change. (Ford 2021.)  
8 Researchers looking at transitioning adolescents found that the weight of biological  
9 male subjects *increased* rather than decreased after treatment with an antiandrogen  
10 testosterone suppressor, with no significant loss of muscle cross-sectional area. (Tack  
11 2018.) Adolescent biological male subjects who were exposed to puberty-halting  
12 medications prior to institution of testosterone suppression presented with lean body  
13 mass 2.5 standard deviations higher than biological girls, and maintained gains of  
14 between 1–2 standard deviations at age 22. (Klaver 2018.) In one recent meta-  
15 analysis, researchers looking at the musculoskeletal effects of hormonal transition  
16 found that even after males had undergone 36 months of therapy, their lean body  
17 mass and muscle area remained above those of females. (Harper 2021.) Another  
18 group in 2004 studied the effects of testosterone suppression to less than 1 nmol/L in  
19 men after one or more years, but still found only a 12% total loss of muscle area by  
20 the end of thirty-six months. (Gooren 2004.) Finally, a 2022 study comparing  
21 biological males on an average of 14.4 years of GAHT to cisgender men and women  
22 showed that, despite testosterone levels that were in female range, both skeletal  
23 muscle mass and appendicular skeletal mass adjusted for height, as well as handgrip  
24 strength, remained statistically greater than cisgender controls. Activity in this  
25 study was controlled for, and did not differ between examined groups. (Alvares 2022)

### 26 **C. Strength**

27 92. A large number of studies have now observed minimal or no reduction  
28 in strength in male subjects following testosterone suppression. In one recent meta-

1 analysis, strength loss after twelve months of hormone therapy ranged from  
2 negligible to 7%. (Harper 2021.) Given the baseline male strength advantage in  
3 various muscle groups of from approximately 25% to 100% above female levels that I  
4 have noted in Section V.D above, even a 7% reduction will leave a large retained  
5 advantage in strength. Another study looking at handgrip strength—which is a proxy  
6 for general strength—showed a 9% loss of strength after two years of hormonal  
7 treatment in males who were transitioning, leaving a 23% retained advantage over  
8 the female baseline. (Hilton 2021.) Yet another study which found a 17% retained  
9 grip strength advantage noted that this placed the median of the group treated with  
10 hormone therapy in the 95<sup>th</sup> percentile for grip strength among age-matched females.  
11 (Scharff 2019.) Researchers looking at transitioning adolescents showed no loss of  
12 grip strength after hormone treatment. (Tack 2018.) One recent study on male Air  
13 Force service members undergoing transition showed that they retained more than  
14 two thirds of pretreatment performance advantage over females in sit-ups and push-  
15 ups after between one and two years of testosterone-reducing hormonal treatment.  
16 (Roberts 2020.) A similar study in 2022 looking at 228 biologically male, transitioning  
17 Air Force personnel showed that these individuals retained statistical advantage over  
18 cis-gender females up to four years for sit-ups, and indefinitely for push-ups, despite  
19 the fact that this group started GAHT underperforming to cisgender males in push-  
20 ups at baseline. (Chiccarelli 2022) An observational cohort study looked at thigh  
21 strength and thigh muscle cross-sectional area in men undergoing hormonal  
22 transition to transgender females. After one year of hormonal suppression, this group  
23 saw only a 4% decrease in thigh muscle cross-sectional area, and a negligible decrease  
24 in thigh muscle strength. (Wiik 2020.) Wiik and colleagues looked at isokinetic  
25 strength measurements in individuals who had undergone at least 12 months of  
26 hormonal transition and found that muscle strength was comparable to baseline, and  
27 torque-generating ability actually increased, leaving transitioned males with a 50%  
28 strength advantage over reference females. (Wiik 2020.) Finally, one cross-sectional

1 study that compared men who had undergone transition at least three years prior to  
2 analysis, to age-matched, healthy males found that the transgender individuals had  
3 retained enough strength that they were still outside normative values for women.  
4 This imbalance continued to hold even after *eight* years of hormone suppression. The  
5 authors also noted that since males who identify as women often have lower baseline  
6 (i.e., before hormone treatment) muscle mass than the general population of males,  
7 and since baseline measures for this study were unavailable, the post-transition  
8 comparison may actually represent an overestimate of muscle mass regression in  
9 transgender females. (Lapauw 2008; Hilton 2021.)

10 93. World Rugby came to the same conclusion based on its own review of the  
11 literature, reporting that testosterone suppression “does not reverse muscle size to  
12 female levels,” and in fact that “studies assessing [reductions in] mass, muscle mass,  
13 and/or strength suggest that reduction in these variables range between 5% and 10%.  
14 Given that the typical male vs female advantages range from 30% to 100%, these  
15 reductions are small.” (World Rugby Transgender Women Guidelines 2020.)

16 94. It is true that most studies of change in physical characteristics or  
17 capabilities over time after testosterone suppression involve untrained subjects  
18 rather than athletes, or subjects with low to moderate training. It may be assumed  
19 that all of the Air Force members who were subjects in the studies I mention above  
20 were physically fit and engaged in regular physical training. But neither those  
21 studies, nor studies looking at athletes quantify the volume or type of strength  
22 training athletes are undergoing. The important point to make is that the only effect  
23 strength training could have on these athletes is to *counteract* and reduce the limited  
24 loss of muscle mass and strength that does otherwise occur to some extent over time  
25 with testosterone blockade. There has been at least one study that illustrates this in  
26 patients undergoing recent androgen deprivation, measuring strength during a  
27 twelve-week period where testosterone was suppressed to levels of 2 nmol/L. During  
28 that time, subjects actually increased leg lean mass by 4%, and total lean mass by

1 2%, and subject performance on the 10 rep-max leg press improved by 32%, while  
2 their bench press performance improved by 17%. (Kvorning 2006.) Another study of  
3 patients on chronic androgen deprivation therapy (mean 1136 days) showed that a 20  
4 week progressive resistance training program moving from concentric toward  
5 eccentric load training resulted in 41% improvements in both chest press and seated  
6 rows, and a 96% improvement in leg press. (Galvao 2006)

7 95. The point for safety is that superior strength enables a biological male  
8 to apply greater force against an opponent's body during body contact, or to throw,  
9 hit, or kick a ball at speeds outside the ranges normally encountered in female-only  
10 play, with the attendant increased risks of injury that I have already explained.

11 **D. Speed**

12 96. As to speed, the study of transitioning Air Force members found that  
13 these males retained a 9% running speed advantage over the female control group  
14 after one year of testosterone suppression, and their average speed had not declined  
15 significantly farther by the end of the 2.5 year study period. (Roberts 2020.) Again, I  
16 have already explained the implications of greater male speed on safety for females  
17 on the field and court, particularly in combination with the greater male body weight.

18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28

## Conclusion

1  
2 Since the average male athlete is larger and exerts greater power than the  
3 average female athlete in similar sports, male-female collisions will produce greater  
4 energy at impact, and impart greater risk of injury to a female, than would occur in  
5 most female-female collisions. Because of the well-documented physiological testing  
6 and elite performance differences in speed and strength, as well as differences in lean  
7 muscle mass that exist across all age ranges, the conclusions of this paper can apply  
8 to a certain extent before, as well as during, and after puberty. We have seen that  
9 males who have undergone hormone therapy in transition toward a female body type  
10 nevertheless retain musculoskeletal “legacy” advantages in muscle girth, strength,  
11 and size. We have also seen that the additive effects of these individual advantages  
12 create multiplied advantages in terms of power, force generation and momentum on  
13 the field of play. In contact or collision sports, sports involving projectiles, or sports  
14 where a stick is used to strike something, the physics and physiology reviewed above  
15 tell us that permitting male-bodied athletes to compete against, or on the same team  
16 as females—even when undergoing testosterone suppression—must be expected to  
17 create predictable, identifiable, substantially increased, and unequal risks of injuries  
18 to the participating women.

19 Based on its independent and extensive analysis of the literature coupled with  
20 injury modeling, World Rugby recognized the inadequacy of the International  
21 Olympic Committee’s policy to preserve safety for female athletes in their contact  
22 sport (the NCAA policy is even more lax in its admission of biological males into the  
23 female category). Among the explicit findings of the World Rugby working group were  
24 the following:

- 25 • Forces and inertia faced by a smaller and slower player during  
26 collisions are significantly greater when in contact with a larger, faster  
27 player.

28

- 1 • Discrepancies in mass and speed (such as between two opponents in a  
2 tackle) are significant determinants of various head and other  
3 musculoskeletal injury risks.
- 4 • The risk of injury to females is increased by biological males' greater  
5 ability to exert force (strength and power), and also by females' reduced  
6 ability to receive or tolerate that force.
- 7 • Testosterone suppression results in only "small" reductions in the male  
8 physiological advantages. As a result, heightened injury risks remain  
9 for females who share the same field or court with biological males.
- 10 • These findings together predict a significant increase in injury rates for  
11 females in rugby if males are permitted to participate based on gender  
12 identity, *with or without testosterone suppression*, since the  
13 magnitude of forces and energy transfer during collisions will increase  
14 substantially, directly correlated to the differences in physical  
15 attributes that exist between the biological sexes.

16 Summarizing their work, the authors of the World Rugby Guidelines said that,  
17 "World Rugby's number one stated priority is to make the game as safe as possible,  
18 and so World Rugby cannot allow the risk to players to be increased to such an extent  
19 by allowing people who have the force and power advantages conferred by  
20 testosterone to play with and against those who do not." (World Rugby Transgender  
21 Guidelines 2020.) As my own analysis above makes clear, I agree with the concerns  
22 of UK Sport and the conclusions of World Rugby regarding risk to female athletes.  
23 Importantly, I also agree that it must be a high priority for sports governing bodies  
24 (and other regulatory or governmental bodies governing sports) to make each sport  
25 as safe as reasonably possible. And in my view, medical practitioners with expertise  
26 in this area have an obligation to advocate for science-based policies that promote  
27 safety.

28



1           The *performance* advantages retained by males who participate in women's  
2 sports based on gender identity are readily recognized by the public. When an NCAA  
3 hurdler who ranked 200<sup>th</sup> while running in the collegiate male division transitions  
4 and immediately leaps to a number one ranking in the women's division;<sup>25</sup> when a  
5 high school male sprinter who ranked 181<sup>st</sup> in the state running in the boys' division  
6 transitions and likewise takes first place in the girls' division (DeVarona 2021), when  
7 a biologically-male collegiate swimmer transitions and moves from 65<sup>th</sup> place in the  
8 men's 500 m event, to NCAA champion in the women's 500 meter race, (Senefeld,  
9 JW., 2023) the problem of fairness and equal opportunities for girls and women is  
10 immediately apparent, and indeed this problem is being widely discussed today in  
11 the media.

12           The causes of sports injuries, however, are multivariate and not always as  
13 immediately apparent. While, as I have noted, some biological males have indeed  
14 competed in a variety of girls' and women's contact sports, the numbers up till now  
15 have been small. But recent studies have reported very large increases in the number  
16 of children and young people identifying as transgender compared to historical  
17 experience. For example, an extensive survey of 9<sup>th</sup> and 11<sup>th</sup> graders in Minnesota  
18 found that 2.7% identified as transgender or gender-nonconforming—well over 100  
19 times historical rates (Rider 2018), and many other sources likewise report this trend.  
20 (Johns 2017; Herman 2017.)

21           Faced with this rapid social change, it is my view as a medical doctor that  
22 policymakers have an important and pressing duty not to wait while avoidable  
23 injuries are inflicted on girls and women, but instead to proactively establish policies  
24 governing participation of biological males in female athletics that give proper and  
25 scientifically-based priority to safety in sport for these girls and women. Separating  
26 participants in contact sports based on biological sex preserves competitive equity,  
27

---

28 <sup>25</sup> [https://en.wikipedia.org/wiki/Cece\\_Telfer](https://en.wikipedia.org/wiki/Cece_Telfer) (accessed 6/20/21)



1 but also promotes the safety of female athletes by protecting them from predictable  
2 and preventable injury. Otherwise, the hard science that I have reviewed in this  
3 white paper leaves little doubt that eligibility policies based on ideology or gender  
4 identity rather than science, will, over time, result in increased, and more serious,  
5 injuries to girls and women who are forced to compete against biologically male  
6 transgender athletes. When basic science and physiology both predict increased  
7 injury, then leagues, policy-makers, and legislators have a responsibility to act to  
8 protect girls and women before they get hurt.

9  
10 I swear or affirm, under penalty of perjury, that the foregoing is true and correct.

11 Dated: May 18, 2023

/s/ Chad Carlson, M.D., FACSM

12 Chad Carlson, M.D., FACSM

13 Stadia Sports Medicine

14 West Des Moines, Iowa

15 Past-President, AMSSM  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28

**Bibliography**

- 1
- 2 Agel, J. et al., Anterior cruciate ligament injury in National Collegiate Athletic
- 3 Association basketball and soccer: a 13-year review. *Am. J. Sports Med.*
- 4 33(4):524-531 (2005).
- 5 Alvares, L.A.M., Cardiopulmonary capacity and muscle strength in transgender
- 6 women on long-term gender-affirming hormone therapy: a cross-sectional
- 7 study. *Br J Sports Med* 56:1292-1299 (2022).
- 8 Athletic Business, "College intramural playing rules vary greatly."
- 9 [https://www.athleticbusiness.com/college/intramural-coed-basketball-playing-](https://www.athleticbusiness.com/college/intramural-coed-basketball-playing-rules-vary-greatly.html)
- 10 [rules-vary-greatly.html](https://www.athleticbusiness.com/college/intramural-coed-basketball-playing-rules-vary-greatly.html).
- 11 Bahr, R. and T. Krosshaug, Understanding injury mechanisms: a key component of
- 12 preventing injuries in sport. *Br. J. Sports Med* 39:324-329 (2005).
- 13 Barboza, S.D. et al., Injuries in field hockey players: a systematic review. *Sports Med.*
- 14 48:849-66 (2018).
- 15 Barth, J.T. et al., Acceleration-deceleration sport-related concussion: the gravity of it
- 16 all. *J. Athletic Training* 36(3):253-56 (2001).
- 17 Beachy, G. and M. Rauh, Middle school injuries: a 20-year (1988-2008) multisport
- 18 evaluation. *J. Athl. Train.* 49(4):493-506 (2014).
- 19 Berz, K. et al., Sex-specific differences in the severity of symptoms and recovery rate
- 20 following sports-related concussion in young athletes. *The Physician and*
- 21 *Sports Med.* 41(2):58-63 (2015).
- 22 BJJ World, "Transgender MMA Fighter Fallon Fox Breaks Skull of Her Female
- 23 Opponent." [https://bjj-world.com/transgender-mma-fighter-fallon-fox-breaks-](https://bjj-world.com/transgender-mma-fighter-fallon-fox-breaks-skull-of-her-female-opponent/)
- 24 [skull-of-her-female-opponent/](https://bjj-world.com/transgender-mma-fighter-fallon-fox-breaks-skull-of-her-female-opponent/).
- 25 Blankenship, M.J. et al., Sex-based analysis of the biomechanics of pitching. 38th
- 26 International Society of Biomechanics in Sport Conference (July 2020).
- 27 Blumenfeld, R.S. et al., The epidemiology of sports-related head injury and
- 28 concussion in water polo. *Front. Neurol.* 7(98) (2016).

- 1 Boden, B.P. et al., Concussion incidence in elite college soccer players. *Am. J. Sports*  
2 *Med.* 26(2):238-241 (1998).
- 3 Bohannon, R.W. et al., Handgrip strength: a comparison of values obtained from the  
4 NHANES and NIH toolbox studies. *Am. J. Occ. Therapy* 73(2) (March/April  
5 2019).
- 6 Bompadre, V. et al., Washington State's Lystedt Law in concussion documentation in  
7 Seattle public high schools. *J. Athletic Training* 49(4):486-92 (2014).
- 8 Broshek, D.K. et al., Sex differences in outcome following sports-related concussion,  
9 *J. Neurosurg.* 102:856-63 (May 2005).
- 10 Buckman, R. F. and Buckman, P.D., Vertical deceleration trauma: principles of  
11 management. *Surg. Clin. N. Am.* 71(2):331-44 (1991).
- 12 Caswell, S.V., et al., Epidemiology of sports injuries among middle school students.  
13 *Brit. J. of Sports Med.* 51(4):305 (2017).
- 14 Catley M., Normative Health-Related Fitness Values for Children: Analysis of 85,437  
15 Test Results on 9-17 Year-Old Australians Since 1985. 47:98-108 (2013).
- 16 Centers for Disease Control, CDC National Health Statistics Report Number 122,  
17 12/20/2018.
- 18 Centers for Disease Control, Nonfatal traumatic brain injuries from sports and  
19 recreation activities—United States, 2001-2005, *JAMA* 298(11):1271-72 (Sept  
20 2007).
- 21 Chevront, S.N. et al., Running performance differences between men and women:  
22 an update. *Sports Med.* 35(12):1017-24 (2005).
- 23 Chiccarelli E., Fit transitioning: When can transgender airmen fitness test in their  
24 affirmed gender? *Mil Med. Usac*320 (2022).
- 25 Chidi-Ogbolu, N. and K. Baar, Effect of estrogen on musculoskeletal performance and  
26 injury risk. *Front. Physiol.* 9:1834 (2019).
- 27 Chu, Y. et al., Biomechanical comparison between elite female and male baseball  
28 pitchers. *J. Applied Biomechanics* 25:22-31 (2009).

1 Coleman, D.L. and W. Shreve, Comparing athletic performances: the best elite women  
2 to boys and men.  
3 [web.law.duke.edu/sites/default/files/centers/sportslaw/comparingathleticperfor](http://web.law.duke.edu/sites/default/files/centers/sportslaw/comparingathleticperformances.pdf)  
4 [mances.pdf](http://web.law.duke.edu/sites/default/files/centers/sportslaw/comparingathleticperformances.pdf). (Accessed 06/20/21)

5 Coleman, D. L. et al., Re-affirming the value of the sports exception to Title IX's  
6 general non-discrimination rule. *Duke J. of Gender and Law Policy* 27(69):69-  
7 134 (2020).

8 Colvin, A.C. et al., The role of concussion history and gender in recovery from soccer-  
9 related concussion. *Am. J. Sports Med.*, 37(9):1699-1704 (2009).

10 Covassin, T. et al., Sex differences and the incidence of concussions among collegiate  
11 athletes. *J. Ath. Training* 38(3):238-244 (2003).

12 Covassin, T. et al., Sex differences in reported concussion injury rates and time loss  
13 from participation: an update of the National Collegiate Athletic Association  
14 Injury Surveillance Program from 2004-2005 through 2009-2009. *J. Ath.*  
15 *Training* 51(3):189-194 (2016).

16 Covassin, T. et al., The role of age and sex in symptoms, neurocognitive performance,  
17 and postural stability in athletes after concussion. *Am. J. Sports Med.*  
18 40(6):1303-1312 (2012).

19 Dashnaw, M.L. et al., An overview of the basic science of concussion and  
20 subconcussion: where we are and where we are going. *Neurosurg. Focus* 33(6)  
21 E5 (2012).

22 Davis, S.M., et al., Sex Differences in Infant Body Composition Emerge in First 5  
23 Months of Life. *J. Pediatr. Endocrinol. Metab.* 32(11): 1235–1239 (2019)

24 DeVarona, D. et al., Briefing book: a request to Congress and the Administration to  
25 preserve girls' and women's sport and accommodate transgender athletes.  
26 *Women's Sports Policy Working Group* (2021).

27 Dick, R.W., Is there a gender difference in concussion incidence and outcomes? *Br. J.*  
28 *Sports Med.* 43(Supp I):i46-i50 (2009).

- 1 DiMiguel-Etayo P., Physical Fitness Reference Standards in European Children: The  
2 IDEFICS Study. *Int J Obes (Lond)* 38(2):557-566 (2014).
- 3 Dohrmann P. Throwing and Kicking Ability of 8 Year Old Boys and Girls. *The*  
4 *Research Quarterly* 35(4):464-471 (1964).
- 5 Dolgin, J., Transgender women on college athletic teams – the case of Lindsay Hecox.  
6 *NEJM* 383(21):2000-2002 (2020).
- 7 Ewing-Cobbs, et al., Persistent postconcussion symptoms after injury. *Pediatrics*  
8 142(5):e20180939 (2018).
- 9 Ferris, D.P. et al., The relationship between physical and physiological variables and  
10 volleyball spiking velocity. *J. Strength & Cond. Research* 9(1):32-36 (1995).
- 11 Fields, J.B. et al., Body composition variables by sport and sport-position in elite  
12 collegiate athletics. *J. Strength & Cond. Research* 32(11):3153-3159 (Nov 2018).
- 13 Figuera, T.M. et al., Bone mass effects of cross-sex hormone therapy in transgender  
14 people: updated systematic review and meta-analysis. *J. Endocrine Soc.*  
15 3(5):943-964 (May 2019).
- 16 Flaxman, T.E. et al., Sex-related differences in neuromuscular control: implications  
17 for injury mechanisms or healthy stabilization strategies? *J. Ortho. Research*  
18 310-317 (Feb 2014).
- 19 Ford, K., Characterising body composition and bone health in transgender  
20 individuals receiving gender-affirming hormone therapy. *J Hum Nutr Diet.*  
21 35:1105-1114 (2022).
- 22 Forthomme, B. et al., Factors correlated with volleyball spike velocity. *AJSM*  
23 33(10):1513-1519 (2005).
- 24 Fung, Y.C., The application of biomechanics to the understanding of injury and  
25 healing. A.M. Nahum et al. (eds), *Accidental Injury*, Springer Science &  
26 Business Media: New York (1993).
- 27 Galvao D.A., Resistance Training and Reduction of Treatment Side Effects in  
28 Prostate Cancer Patients. *Med Sci Sports Exerc.* 38(12):2045-52.

- 1 Gay, T., *Football physics: the science of the game*. Rodale Books (2004).
- 2 Gershoni, M. The landscape of sex-differential transcriptome and its consequent  
3 selection in human adults. *BMC Biology*. 15(7) (2017).
- 4 Gilsanz, V. et al., Age at onset of puberty predicts bone mass in young adulthood. *J.*  
5 *Pediatr.* 158(1):100-105 (Jan 2011).
- 6 Gooren, L.J.G. et al., Transsexuals and competitive sports. *Eur. J. Endocrinol.*  
7 151:425-9 (2004).
- 8 Hacherl, S.L., et al., Concussion rates and sports participation time loss in sex-  
9 comparable middle school sports. *Archives of Clinical Neuropsychology* 36:650  
10 (2021).
- 11 Hacherl, S.L., et al., Concussion rates in U.S. middle school athletes from the 2015-  
12 16 to 2019-20 school years. *J. Athl. Train.* 56(6s):S-21 (2021).
- 13 Handelsman, D.J. et al., Circulating testosterone as the hormonal basis of sex  
14 differences in athletic performance. *Endocrine Reviews* 39(5):803-829 (Oct  
15 2018).
- 16 Harmon, K.G. et al., American Medical Society for Sports Medicine position  
17 statement: concussion in sport. *Br. J. Sports Med.* 47:15-26 (2013).
- 18 Harper, J. et al., How does hormone transition in transgender women change body  
19 composition, muscle strength and haemoglobin? Systematic review with a  
20 focus on the implications for sport participation. *BJSM* 55(15):865-72 (2021).
- 21 Heather A.K. Transwoman Elite Athletes: Their Extra Percentage Relative to Female  
22 Physiology. *Int J Environ Res Public Health* 19:9103 (2022)
- 23 Herman, JL et al., Age of Individuals Who Identify As Transgender in the United  
24 States. The Williams Institute (2017).
- 25 Herzberg, S.D. et al., The effect of menstrual cycle and contraceptives on ACL injuries  
26 and laxity: a systematic review and meta-analysis. *Orthop. J. Sports Med.* 5(7)  
27 (2017).
- 28 Hewett, T.E. et al., Biomechanical measures of neuromuscular control and valgus

1 loading of the knee predict anterior cruciate ligament injury risk in female  
2 athletes: a prospective study. *AJSM* 33(4):492-501 (2005).

3 Hilton, E. N. and T.R. Lundberg, Transgender women in the female category of sport:  
4 perspectives on testosterone suppression and performance advantage. *Sports*  
5 *Medicine* 51:199-214 (2021).

6 Hon, W.H.C. and S.H. Kock, Sports related fractures: a review of 113 cases. *J.*  
7 *Orhopaedic Surg.* 9(1):35-38 (2001).

8 Howell, D.R. et al., Collision and contact sport participation and quality of life among  
9 adolescent athletes. *J. Athletic Training* 55(11):1174-1180 (2020).

10 Hult, J.S., Women's struggle for governance in U.S. amateur athletics. *Int. Rev. for*  
11 *Soc. of Sports* 24(3):249-61 (1989).

12 International Olympic Committee. IOC Framework on Fairness, Inclusion and Non-  
13 Discrimination on the Basis of Gender Identity and Sex Variations (2021).

14 Janssen, I. et al., Skeletal muscle mass and distribution in 468 men and women aged  
15 18-88 yr. *J. Appl. Physiol.* 89:81-88 (2000).

16 Johns, M., Transgender Identity and Experiences of Violence Victimization,  
17 Substance Use, Suicide Risk, and Sexual Risk Behaviors Among High School  
18 Students – 19 States and Large Urban School Districts. *MMWR* 2019;68:67-71  
19 (2019).

20 Kasovic M et al., Secular Trends in Health-Related Physical Fitness Among 11-14  
21 Year-Old Croatian Children and Adolescents From 1999 to 2014. *Scientific Rep*  
22 11:11039 (2021)

23 Kellis, S.E. et al., The evaluation of jumping ability of male and female basketball  
24 players according to their chronological age and major leagues. *J. Strength and*  
25 *Conditioning Res.* 13(1):40-46 (1999).

26 Kerr, Z., et al., Concussion rates in U.S. middle school athletes, 2015-16 school year,  
27 *Am. J. Prev. Med.* 53(6):914-18 (2017).

28 Kirchengast, S., Sexual dimorphism in body composition, weight status and growth



- 1 in prepubertal school children from rural areas of eastern Austria. *Collegium*  
2 *Antropologicum* 25(1):21-30 (2001).
- 3 Klaver M., Early hormonal treatment affects body composition and body shape in  
4 young transgender adolescents. *J Sex Med.* 15(2):251-260 (2018).
- 5 Kobayashi, H. et al., Mechanisms of the anterior cruciate ligament injury in sports  
6 activities: A twenty-year clinical research of 1700 athletes. *J. Sports Science &*  
7 *Medicine* 9:669-675 (2010).
- 8 Kountouris, P. et al., Evidence for differences in men's and women's volleyball games  
9 based on skills effectiveness in four consecutive Olympic tournaments.  
10 *Comprehensive Psychology* 4(9) (2015).
- 11 Kuczinski, A. et al., Trends and epidemiologic factors contributing to soccer-related  
12 fractures that presented to emergency departments in the United States.  
13 *Sports Health* 11(1):27-31 (2018).
- 14 Kujala U.M., et al., Acute injuries in soccer, ice hockey, volleyball, basketball, judo,  
15 and karate: analysis of national registry data. *BMJ* 311(7018):1465-68 (1995).
- 16 Kvorning, T. et al., Suppression of endogenous testosterone production attenuates  
17 the response to strength training: a randomized, placebo-controlled, and  
18 blinded intervention study. *Am. J. Physiol .Metab.* 291:E1325-E1332 (2006).
- 19 La Fountaine, M.F. et al., Preliminary evidence for a window of increased  
20 vulnerability to sustain a concussion in females: a brief report. *Front. Neurol.*  
21 10:691 (2019).
- 22 Lapauw, B. et al., Body composition, volumetric and areal bone parameters in male-  
23 to-female transsexual persons. *Bone* 43:1016-21 (2008).
- 24 Lin, C. et al., Sex differences in common sports injuries. *PM R* 10(10):1073-1082  
25 (2019).
- 26 Lombardo, M.P. and R. O. Deaner, On the evolution of sex differences in throwing.  
27 *Qu. Review of Bio.* 93(2):91-119 (2018).
- 28 Los Angeles Times, "Volleyball star Haley Hodson had it all, until blows to her head

- 1 changed everything." [https://www.latimes.com/sports/story/2020-12-](https://www.latimes.com/sports/story/2020-12-08/stanford-volleyball-hayley-hodson-concussions-cte-lawsuit)  
2 [08/stanford-volleyball-hayley-hodson-concussions-cte-lawsuit](https://www.latimes.com/sports/story/2020-12-08/stanford-volleyball-hayley-hodson-concussions-cte-lawsuit).
- 3 Magnusson, S.P. et al., The adaptability of tendon loading differs in men and women.  
4 Int. J. Exp. Pathol. 88:237-40 (2007).
- 5 Marar, M. et al., Epidemiology of concussions among United States high school  
6 athletes in 20 sports. Am. J. Sports Med. 40(4):747-755 (2012).
- 7 McCrory, P. et al., Consensus statement on concussion in sport—the 5th  
8 international conference on concussion in sport held in Berlin, October 2016.  
9 BJSM 51:838-847 (2018).
- 10 McGroarty, N.K. et al., Sport-related concussion in female athletes: a systematic  
11 review. Orthop. J. Sports Med. 8(7) (2020).
- 12 McIntosh, A.S., Risk compensation, motivation, injuries, and biomechanics in  
13 competitive sport, Br. J. Sports Med (39):2-3 (2005).
- 14 McLarnon M., A Scoping Review of Transgender Policies in the 15 most commonly  
15 played UK Professional Sports. Int J Environ Res Public Health 20, 3568  
16 (2023).
- 17 McManus, A. and N. Armstrong, Physiology of elite young female athletes. J Med &  
18 Sport Sci 56:23-46 (2011).
- 19 Meeuwse, W.H., Assessing causation in sports injury: a multifactorial model.  
20 Clinical J. of Sports Med. 4(3):166-70 (1994).
- 21 Montalvo, A.M. et al., Anterior cruciate ligament injury risk in sport: a systematic  
22 review and meta-analysis of injury incidence by sex and sport classification. J.  
23 Ath. Training 54(5):472-482 (2019).
- 24 Montalvo, A.M. et al., "What's my risk of sustaining an ACL injury while playing  
25 sports?": a systematic review with meta-analysis. Br. J. Sports Med. 53:1003-  
26 1012 (2019).
- 27 Mooney, J. et al., Concussion in soccer: a comprehensive review of the literature.  
28 Concussion 5(3) (2020).

- 1 Morris, J.S. et al., Sexual dimorphism in human arm power and force: implications for  
2 sexual selection on fighting ability. *J. Exp. Biol.* 223(Pt 2) (2020).
- 3 National Collegiate Athletic Association, Inclusion of transgender student-athletes.  
4 [https://ncaaorg.s3.amazonaws.com/inclusion/lgbtq/INC\\_TransgenderHandbook.pdf](https://ncaaorg.s3.amazonaws.com/inclusion/lgbtq/INC_TransgenderHandbook.pdf)  
5 [k.pdf](https://ncaaorg.s3.amazonaws.com/inclusion/lgbtq/INC_TransgenderHandbook.pdf) (August 2011).
- 6 National Conference of State Legislatures, Report on traumatic brain injury  
7 legislation. [https://www.ncsl.org/research/health/traumatic-brain-injury-](https://www.ncsl.org/research/health/traumatic-brain-injury-legislation.aspx#1)  
8 [legislation.aspx#1](https://www.ncsl.org/research/health/traumatic-brain-injury-legislation.aspx#1) (2018).
- 9 Neder, J.A. et al., Reference values for concentric knee isokinetic strength and power  
10 in nonathletic men and women from 20 to 80 years old. *J. Orth. & Sports Phys.*  
11 *Therapy* 29(2):116-126 (1999).
- 12 New York Times, “Estimate of U.S. transgender population doubles to 1.4 Million  
13 adults.” [https://www.nytimes.com/2016/07/01/health/transgender-](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
14 [population.html?mc=aud\\_dev&ad-](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
15 [keywords=auddevgate&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
16 [zB9LI5Ut57OQzuMhurWThvBMisV9NyN9YTXIzWl7OAnGT6VkaAu0jEAL](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
17 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
18 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
19 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
20 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
21 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
22 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
23 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
24 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
25 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
26 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
27 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
28 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
29 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
30 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
31 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
32 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
33 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
34 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
35 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
36 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
37 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
38 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
39 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
40 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
41 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
42 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
43 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
44 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
45 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
46 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
47 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
48 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
49 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
50 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
51 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
52 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
53 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
54 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
55 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
56 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
57 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
58 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
59 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
60 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
61 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
62 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
63 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
64 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
65 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
66 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
67 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
68 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
69 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
70 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
71 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
72 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
73 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
74 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
75 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
76 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
77 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
78 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
79 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
80 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
81 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
82 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
83 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
84 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
85 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
86 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
87 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
88 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
89 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
90 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
91 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
92 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
93 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
94 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
95 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
96 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
97 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
98 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
99 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)  
100 [w\\_wcB&gclid=Cj0KCQjwkZiFBhD9ARIsAGxFX8BV5po](https://www.nytimes.com/2016/07/01/health/transgender-population.html?mc=aud_dev&ad-)
- 18 Nieves, J.W. et al., Males have larger skeletal size and bone mass than females,  
19 despite comparable body size. *J. Bone Mineral Res.* 20(3):529-35 (2005).
- 20 Palao, J.M. et al., Normative profiles for serve speed for the training of the serve and  
21 reception in volleyball. *The Sport Journal* (July 2014).
- 22 Pierpoint, L. et al., The first decade of web-based sports injury surveillance:  
23 descriptive epidemiology of injuries in US high school boys’ (and girls) lacrosse  
24 (2008–2009 Through 2013–2014) and National Collegiate Athletic Association  
25 men’s lacrosse (2004–2005 Through 2013–2014). *J. Athl. Training* 54(1):30-41  
26 (2019).
- 27 Pigozzi F et al., Joint Position Statement of the International Federation of Sports  
28 Medicine (FIMS) and European Federation of Sports Medicine Associations

- 1 (EFSMA) on the IOC Framework on Fairness, Inclusion and Non-  
2 discrimination Based on Gender Identity and Sex Variations. *BMJ Open Sp*  
3 *Ex Med* 8:e001273 (2022).
- 4 Preiss-Farzanegan, S.J. et al., The relationship between gender and postconcussion  
5 symptoms after sport-related mild traumatic brain injury. *PM R* 1(3):245-53  
6 (2009).
- 7 Rider, G.N. et al., Health and care utilization of transgender and gender  
8 nonconforming youth: a population-based study. *Pediatrics* 141:3 (March 2018).
- 9 Roberts, T.A. et al., Effect of gender affirming hormones on athletic performance in  
10 transwomen and transmen: implications for sporting organizations and  
11 legislators. *BJSM* 0:1-7 (2020).
- 12 Rowson, S. et al., Biomechanical perspectives on concussion in sport, *Sports Med.*  
13 *Arthrosc.* 24(3):100-107 (Sept 2016).
- 14 Ruetsche, A.G. et al., Cortical and trabecular bone mineral density in transsexuals  
15 after long-term cross-sex hormonal treatment: a cross-sectional study.  
16 *Osteoporos. Int.* 16:791-798 (2005).
- 17 Sakamoto, K. et al., Comparison of kicking speed between female and male soccer  
18 players. *Procedia Engineering* 72:50-55 (2014).
- 19 Santos, D.A. et al., Reference values for body composition and anthropometric  
20 measurements in athletes. *PLOSOne* 9(5) (May 2014).
- 21 Sattler, T. et al., Vertical jump performance of professional male and female  
22 volleyball players: effects of playing position and competition level. *J. Strength*  
23 *and Conditioning Res.* 29(6):1486-93 (2015).
- 24 Scharff, M. et al., Change in grip strength in trans people and its association with  
25 lean body mass and bone density. *Endocrine Connections* 8:1020-28 (2019).
- 26 Senefeld, J.W., Case studies in physiology: Male to female transgender swimmer in  
27 college athletics. *J Appl Physiol* 134:1032-1037 (2023).
- 28 Singh-Ospina, N. et al., Effect of sex steroids on the bone health of transgender

- 1 individuals: a systematic review and meta-analysis. *J. Clin. Endocrinol.*  
2 *Metab.* 102(11):3904-13 (Nov 2017).
- 3 Sutton, K.M. et al., Anterior cruciate ligament rupture: differences between males  
4 and females. *J. Am. Acad. Orthop. Surg.* 21(1):41-50 (2013).
- 5 Tack, L.J.W. et al., Proandrogenic and antiandrogenic progestins in transgender  
6 youth: differential effects on body composition and bone metabolism. *J. Clin.*  
7 *Endocrinol. Metab.*, 103(6):2147-56 (2018).
- 8 Tambalis K et al., Physical Fitness Normative Values for 6-18 Year Old Greek Boys  
9 and Girls. *Eur J Sport Sci* 16(6):736-46 (2016).
- 10 Taylor, R.W., et al., Gender differences in body fat content are present well before  
11 puberty. *Int. J. Obes. Relat. Metab. Disord.* 21(11): 1082-4 (1997).
- 12 Taylor, R.W., et al., Sex differences in regional body fat distribution from pre- to  
13 postpuberty. *Obesity* 18(7): 1410-16 (2010).
- 14 Thomas, J.R. and K. E. French, Gender differences across age in motor performance:  
15 a meta-analysis. *Psych. Bull.* 98(2):260-282 (1985).
- 16 Tierney, R.T. et al., Gender differences in head-neck segment dynamic stabilization  
17 during head acceleration. *Med. and Sci. in Sports and Exercise*, American  
18 College of Sports Medicine 37(2):272-9 (2005).
- 19 UK Sports Councils' Equality Group, Guidance for Transgender Inclusion in  
20 Domestic Sport,  
21 [https://equalityinsport.org/docs/300921/Guidance%20for%20Transgend](https://equalityinsport.org/docs/300921/Guidance%20for%20Transgender%20Inclusion%20in%20Domestic%20Sport%202021.pdf)  
22 [er%20Inclusion%20in%20Domestic%20Sport%202021.pdf](https://equalityinsport.org/docs/300921/Guidance%20for%20Transgender%20Inclusion%20in%20Domestic%20Sport%202021.pdf) (2021).
- 23 UK Sports Councils' Equality Group, International Research Literature Review,  
24 [https://equalityinsport.org/docs/300921/Transgender%20International%](https://equalityinsport.org/docs/300921/Transgender%20International%20Research%20Literature%20Review%202021.pdf)  
25 [20Research%20Literature%20Review%202021.pdf](https://equalityinsport.org/docs/300921/Transgender%20International%20Research%20Literature%20Review%202021.pdf) (2021).
- 26 Van Caenegem E et al., Preservation of Volumetric Bone Density and Geometry in  
27 Trans Women During Cross-Sex Hormonal Therapy: A Prospective  
28 Observational Study. *Osteoporos Int* 26:35-47 (2015).

- 1 Van Den Tillaar, R. and J. M. H. Cabri, Gender differences in the kinematics and ball  
2 velocity of overarm throwing in elite team handball players. *J. Sports Sciences*  
3 30(8):807-813 (2012).
- 4 Viviers, P. et al., A review of a decade of rugby union injury epidemiology: 2007-2017.  
5 *Sports Health* 10(3):223-27 (2018).
- 6 VolleyballMag.com, "Hit by volleyballs: concussions have changed coach Corinne  
7 Atchison's life." <https://volleyballmag.com/corinneatchison/> (9/25/16).
- 8 Wang, L. et al., Post-traumatic osteoarthritis following ACL injury. *Arthritis Res. and*  
9 *Therapy* 22(57) (2020)
- 10 Wiik, A., T. R Lundberg et al., Muscle strength, size, and composition following 12  
11 months of gender-affirming treatment in transgender individuals. *J. Clinical*  
12 *Endocrin. & Metab.* 105(3):e805-813 (2020).
- 13 Wikipedia, "Cece Telfer." [https://en.wikipedia.org/wiki/Cece\\_Telfer](https://en.wikipedia.org/wiki/Cece_Telfer).
- 14 Wolf, J.M. et al., Male and female differences in musculoskeletal disease. *J. Am. Acad.*  
15 *Orthop. Surg.* 23:339-347 (2015).
- 16 World Rugby Transgender Guidelines. [https://www.world.rugby/the-game/player-](https://www.world.rugby/the-game/player-welfare/guidelines/transgender)  
17 [welfare/guidelines/transgender](https://www.world.rugby/the-game/player-welfare/guidelines/transgender) (2020).
- 18 World Rugby Transgender Women Guidelines. [https://www.world.rugby/the-](https://www.world.rugby/the-game/player-welfare/guidelines/transgender/women)  
19 [game/player-welfare/guidelines/transgender/women](https://www.world.rugby/the-game/player-welfare/guidelines/transgender/women) (2020).
- 20 Wunderle, K. et al, Menstrual phase as predictor of outcome after mild traumatic  
21 brain injury in women. *J. Head Trauma Rehabil.* 29(5):E1-E8 (2014).
- 22  
23  
24  
25  
26  
27  
28