Nos. 24-38, 24-43

# In the Supreme Court of the United States

BRADLEY LITTLE, in his official capacity as Governor of the State of Idaho, et al.,

*Petitioners*

*v.*

LINDSAY HECOX, et al.

*Respondents.*

STATE OF WEST VIRGINIA, et al.,

*Petitioners*,

*v.*

B.P.J., by next friend and mother, HEATHER JACKSON,

*Respondent*.

On Writs of Certiorari to the United States Court of Appeals for the Fourth and Ninth Circuits

## BRIEF OF DOCTORS OF SPORTS MEDICINE AS *AMICI CURIAE* IN SUPPORT OF PETITIONER

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## INTEREST OF *AMICI CURIAE*[1]

*Amici curiae* are medical doctors who specialize in sports medicine, including four past Presidents of the largest organization of sports medicine physicians in the world, the American Medical Society for Sports Medicine (AMSSM).[2]

Dr. Chad Carlson has served as a team physician for both the University of Illinois and Ball State University. He is a past-President (2019-20), former board member, and fellow of the AMSSM. He has also been designated a Fellow of the American College of Sports Medicine (ACSM), where he has served on the Health and Science Policy Committee since 2010. Dr. Carlson has published several articles and books on topics related to musculoskeletal injuries in sports and rehabilitation in multiple peer-reviewed journals.

Dr. Tracy Ray is a retired sports medicine physician with 30 years of experience taking care of athletes at all levels. Dr. Ray was an Associate Professor in the Departments of Orthopedic Surgery and Family Medicine at Duke University, where he directed the Primary Care Sports Medicine Fellowship Program and served as a team physician with Duke Athletics. He was on the Board of Trustees for the ACSM and also served as the President of AMSSM (2020-21).

Dr. Chad Asplund served as the executive director of the U.S. Council for Athletes' Health. He is

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[1] No party or counsel for a party authored this brief in whole or in part. No one other than *Amici* or their counsel made a monetary contribution to preparing or submitting this brief.

[2] *Amici* appear in their individual capacities. Institutional affiliations are listed for identification purposes only.

currently Lead Physician, Washington Mystics (WNBA), and the team physician at Georgetown University. He is a past-President (2018-19) of the AMSSM. Dr. Asplund is the author of more than 75 peer-reviewed articles and has held academic appointments with seven institutions, including Mayo Clinic.

Dr. Robert Dimeff currently serves as a team physician for the NHL Dallas Stars. He also served as team physician for the NFL Cleveland Browns, NBA Cleveland Cavaliers, WNBA Cleveland Rockers, and Cleveland State University. From 2009 to 2018, he was the Director of Primary Care Sports Medicine at the University of Texas Southwestern Medical Center in Dallas, where he was a Professor of Orthopedic Surgery, Pediatrics, and Family & Community Medicine. He is a past-President (2008-09) and board member of the AMSSM. Dr. Dimeff has authored over 40 academic articles.

Dr. Nathaniel Nye is a Sports Medicine physician currently serving as team physician for Southern Utah University. He previously served 13 years as an active duty physician in the US Air Force. He has published over 40 peer-reviewed journal articles and delivered numerous national lectures on a range of sports medicine topics. He currently serves on the AMSSM Board of Directors and is an Associate Professor of Family Medicine (Uniformed Services University, Bethesda, Maryland).

Dr. Jeremy Henrichs is a board-certified sports medicine physician with over 20 years of experience as a team physician for high school, collegiate, and elite athletes. For the past 13 years, he has served as the team physician for the University of Illinois, where he is also a clinical professor at the Carle Illinois College of Medicine. He has served on the Practice and Policy committee of AMSSM, and he was the AMSSM representative to the 2020 NCAA Summit on Gender Identity and Student-Athlete Participation.

*Amici* seeks to bring to the Court's attention the scientific literature documenting how differences between males and females affect sports safety, in particular, the increased risk of injury to female athletes when they compete against biologically male transgender athletes.[3]

## SUMMARY OF ARGUMENT

Sport governing bodies, including those associated with public schools, have always ensured both safety and competitive balance by grouping athletes together based on physical attributes, such as age, weight, and sex. Now, however, many schools and sports leagues permit males to compete in female athletics based on gender identity. Indeed, the courts below held that allowing males to compete in female sports is *required* by the Equal Protection Clause and Title IX. These

[3] We use the terms "male" and "female" according to their ordinary medical meaning—that is to say, to refer to the two biological sexes. We also use the words "man" or "boy" to refer to a biologically male human, and "woman" or "girl" to refer to a biologically female human. In the context of this brief, we include in these categories non-syndromic, biologically normal males and females who self-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 we avoid for purposes of this brief, which is focused on sports science.

courts reasoned that there is no sufficiently important state interest that would justify the exclusion of such males from competing in women's sports.

Numerous scientific studies, however, show that, even before puberty, males are, on average, bigger, faster, and stronger than females. They are taller, have bigger, denser, stronger, and longer bones, and can throw faster and kick harder than women. Numerous studies show that no amount of testosterone suppression will eliminate these male athletic advantages.

These immutable sex differences have significant implications for athlete safety. The science of sports injuries shows that the risk of injury increases with the amount of energy and force brought to a collision. Simply put, due to their inherent biological differences, men and boys, on average, bring more energy and force to a collision than women and girls, whether through bodily contact, thrown or kicked balls, or stick contact. Studies show that women are already more susceptible to sports-related injuries. Allowing males to compete in female athletics will increase injuries to women.

## ARGUMENT

To some extent, sport governing bodies have always recognized the importance of grouping athletes based on physical attributes to ensure both safety and competitive balance. Weight classifications have long existed in many sports. Children don't play against adults, especially in contact sports. Women and men have participated in separate categories since the advent of intercollegiate sporting clubs in the late 1800's.

These categorical separations are motivated in part by average performance differences and considerations of fairness and opportunity. But they are also motivated by safety concerns. These divisions enhance safety because, when it comes to physical traits such as body size, weight, speed, muscle girth, and bone strength, although a certain amount of variability exists within each group, the averages and medians differ widely between the separated groups. Introducing individuals from one group who are categorically larger, faster, and stronger into another group (e.g., an adult onto a youth football team, or males into most women's sports) statistically increases the injury risk for the original athletes in that group.

The rationale for sex-designation in sports is reflected in the original implementing regulations of Title IX, which, acknowledging biologically driven differences between the sexes, created carve-out exceptions authorizing sex-separation of sport for reasons rooted in the maintenance of competitive equity. 34 C.F.R. § 106.41 (allowing for sex-separated sports teams where selection is "based upon competitive skill or the activity involved is a contact sport"). Importantly, the effect of these innate sex-based differences on the health and safety of the athlete was acknowledged by the express authorization of sex-separated teams for sports with higher injury risk—i.e., "contact sports." *Ibid.*

In the almost half-century since those regulations were adopted, the persistent reality of sex-determined differences in athletic performance and safety has been recognized by the ongoing and nearly universal separation of men's and women's teams—even those that are not classically defined as being part of a contact or collision sport. Now, however, many schools and sports leagues in this country are permitting males to compete in female athletics—including in contact sports—based on gender identity. These policies raise significant safety implications.

## I. Significant differences between males and females in strength, speed, and other performance measures exist even before puberty.

Although most easily documented in athletes who have gone through puberty, sex-determined differences in athletic performance and safety are not exclusively limited to post-pubertal athletes. Global population-based fitness testing over wide geographical regions and across time reveals consistent measurable performance advantages of boys over girls in tests measuring speed, upper and lower body limb strength and power, reaching statistical significance as early as age three. *See* James L. Nuzzo & Matheus D. Pinto, *Sex Differences in Upper- and Lower-Limb Muscle Strength in Children and Adolescents: A Meta-Analysis*, 25(5) Eur. J. Sport Sci. 1 (2025); Thea Fühner et al., *Age and sex effects in physical fitness components of 108,295 third graders including 515 primary schools and 9 cohorts*, 11 Sci. Reports article 17566 (2021); Mario Kasovic et al., *Secular trends in health-related physical fitness among 11-14-year-old Croatian children and adolescents from 1999 to 2014*, 11 Sci. Reports article 11039 (2021); P.A. Latorre Roman et al., *Physical fitness in preschool children: association with sex, age and weight status*, 43(2) Child: Care, Health and Development 267 (2017); Konstantinos D. Tambalis et al., *Physical fitness normative values for 6–18-year-old Greek boys and girls, using the empirical distribution and the lambda, mu, and sigma statistical method*, 16(6) Eur. J. Sports Sci. 736 (2016).

Prospective data involving the training of eight-year-old boys and girls in kicking and throwing ability shows consistently higher performance of boys over girls at baseline, and similar gains from baseline in both sexes after coaching. *See* Paul Dohrmann, *Throwing and Kicking Ability of 8 Year Old Boys and Girls*, 35(4) The Research Quarterly 464 (1964). Studies also show that prepubertal males run faster, jump higher and farther, exhibit higher aerobic power output, and have greater upper body strength than comparably aged females. *See*, *e.g.*, Gregory A. Brown et al. *Sex-based differences in shot put, javelin throw, and long jump in 8-and-under and 9-10-year-old athletes*, 25(1) Eur. J. Sport Sci. 1 (2025); Mira A. Atkinson et al., *Sex Differences in Track and Field Elite Youth*, 56(8) Med. Sci. Sports Exercise 1390 (2024); Mark J. Catley & Grant R. Tomkinson, *Normative health-related fitness values for children: analysis of 85347 test results on 9-17-year-old Australians since 1985*, 47 Br. J. Sports Med. 98 (2013).

In sum, a large and unbridgeable performance gap between the sexes is well-documented, beginning in many cases before puberty. Some of these differences touch on the question of athlete safety.

## II. Sex-based differences increase the risk of injury to women and girls when competing against men and boys.

### A. The physics of sports injury

Sports injuries often result from collisions between players or between a player and a rapidly moving object, such as a ball. Basic principles of physics can help identify factors that predictably increase the relative risk, frequency, and severity of sports injuries from such collisions.

The energy embodied in a moving object (whether a human body, a ball, or anything else) is called kinetic energy. The kinetic energy of a moving object is expressed as:

$$E = \frac{1}{2} mv^2$$

That is, kinetic energy is a function of the mass of the object multiplied by the square of its velocity.

The implication of this equation is that what appear to be relatively minor differences in size and speed can result in major differences in energy imparted in a collision. M.L. Dashnaw et al., *An overview of the basic science of concussion and subconcussion: where we are and where we are going*, 33(6) Neurosurgical Focus 1, 2 (2012). Thus, the average differences between men and women lead to the potential for large differentials in force. If Player A weighs 20% more than Player B, and runs 15% faster, Player A will bring 58% more kinetic energy into a collision than Player B.

In the case of a collision between players, or between (e.g.) a ball and a player's head, some of the energy "lost" by one player, or by the ball, may result in deformation of the player's body—which, depending on its severity, may result in injury. Thus, the greater the kinetic energy brought into a collision, the greater the potential for injury, all else equal.

Collisions also involve force and acceleration, which are particularly relevant to concussion injuries. When two athletes collide, their bodies necessarily accelerate (or decelerate) rapidly: stopping abruptly, bouncing back, or being deflected in a different direction. The amount of force in the impact is equal to the mass multiplied by acceleration, where acceleration refers to the rate of change in speed (or velocity), i.e.,

$$F = ma.$$

The implication of this equation is that when a larger and a smaller body collide, and (necessarily) experience equal and opposite forces, the smaller body (or smaller player, in sport) will experience more rapid acceleration. The equation also tells us that if a given player's body or head is hit with a larger force (e.g., from a ball that has been thrown or hit faster), it will experience greater acceleration, all else equal.

Of course, sport is chaotic, and forces are often not purely linear. Many collisions involve angular velocities, with the production of rotational force, or torque. Torque can be thought of as force that causes rotation around a central point. A different but similar equation governs the principles involved:

$$\tau = I\alpha.$$

That is, torque equals moment of inertia multiplied by angular 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.

Injury can occur when torque is applied through joints in directions that those joints are not able to accommodate. Torque can also cause different parts of the body to accelerate at different rates—in some cases, very rapid rates, also leading to injury. For example, a collision where the body is impacted at the waist can result in high torque and acceleration on the neck and head.

### B. Sex-based differences related to injury

It is self-evident to most people familiar with sport and sport injuries that if men and women were to consistently participate together in competitive contact sports, there would be higher rates of injury in women. Understanding the physics of sports injuries helps provide a theoretical framework for why this is true. Not surprisingly, our common sense about the human condition is consistent with the observations of medical science.

### 1. Sex-based differences increase the risk of injury to females competing with males.

#### a. Height, weight, and bone strength

Males as a group are statistically larger and heavier than females. On average, men are 7% to 8% taller than women. *See* David J. Handelsman et al., *Circulating testosterone as the hormonal basis of sex differences in athletic performance*, 39(5) Endocrine Reviews 803, 818 (2018). According to recently available statistics, the weight of the average U.S. adult male is 16% greater than that of the average U.S. adult female. *See* Centers for Disease Control, CDC National Health Statistics Report Number 122 (2018). This disparity persists in the athletic cohort. The weight difference between the average adult male and female athlete remains within the same range— between 14% and 23%, depending on the sport analyzed. Diana A. Santos et al., *Reference values for body composition and anthropometric measurements in athletes*, 9(5) PLOS One e97846 (2014); Jennifer B. Fields et al., *Body composition variables by sport and sport-position in elite collegiate athletics*, 32(11) J. Str. & Cond. Res. 3153 (2018). This size advantage by itself allows men to bring more force to bear in a collision.

Male bones are larger and stronger per unit of volume. Studies of differences in arm and leg bone mineral density—one component of bone strength—find that male bones are denser, with measured advantages of between 5% and 14%. Vincente Gilsanz et al., *Age at onset of puberty predicts bone mass in young adulthood*, 158(1) J. Pediatrics 100 (2011); Jeri W. Nieves et al., *Males have larger skeletal size and bone mass than females, despite comparable body size*, 20(3) J. Bone & Mineral Res. 529, 530-33 (2005). "The major effects of men's larger and stronger bones would be manifest via their taller stature as well as the larger fulcrum with greater leverage for muscular limb power exerted in jumping, throwing, or other explosive power activities." Handelsman, *supra*, at 818. Men can thus generate greater kinetic energy and force in collisions.

**b. Speed**

When it comes to acceleration from a static position to a sprint, men are consistently faster than women. World record sprint performance gaps between the sexes remain significant at between 7% and 10.5%, with world record times for women now exhibiting a plateau (no longer rapidly improving with time) similar to the historical trends seen in men. *See* Samuel N. Cheuvront et al., *Running performance differences between men and women: an update*, 35(12) Sports Med. 1017 (2005). This performance gap has to do with, among other factors, increased skeletal stiffness, greater cross-sectional muscle area, denser muscle fiber composition, and greater limb length. *See* Handelsman, *supra*, at 811-18. Collectively, males, on average, run about 10% faster than females. *See* Michael P. Lombardo & Robert O. Deaner, *On the evolution of sex differences in throwing*, 93(2) Q. Rev. Bio. 91, 93 (2018). This becomes important as it pertains to injury risk, because males involved in sport will often be travelling at faster speeds than their female counterparts in comparable settings, with resultant faster speed at impact and greater impact force, in a given collision.

### c. Strength and power

In absolute terms, males as a group are substantially stronger than women. Compared to women, men have "larger and denser muscle mass, and stiffer connective tissue, with associated capacity to exert greater muscular force more rapidly and efficiently." Emma N. Hilton & Tommy R. Lundberg, *Transgender women in the female category of sport: perspectives on testosterone suppression and performance advantage*, 51 Sports Med. 199, 201 (2021). During the prime athletic years (ages 18–29) men have, on average, 54% greater total muscle mass than women, including 64% greater muscle mass in the upper body, and 47% greater in the lower body. Ian Janssen et al., *Skeletal muscle mass and distribution in 468 men and women aged 18-88 yr*, 89 J. Appl. Physiol. 81, 83 (2000) (Table 1). The cross-sectional area of muscle in women is only 50% to 60% that of men in the upper arm, and 65% to 70% of that of men in the thigh. This translates to women having only 50% to 60% of men's upper limb strength and 60% to 80% of men's lower limb strength. Handelsman, *supra*, at 812. Male weightlifters have been shown to be approximately 30% stronger than female weightlifters of equivalent stature and mass, in part related to a greater proportion of fast-contracting type II muscle fibers. Hilton, *supra*, at 203; Sandra K. Hunter & Jonathon W. Senefeld, *Sex differences in human performance*, 602(17) J. Physiol. 4129, 4139 (2024).

Looking at other common metrics of strength, males average 57% greater grip strength, Raju Vaishya et al., *Hand grip strength as a proposed new vital sign of health: a narrative review of evidences*, 43 J. Health, Population and Nutrition article 7 (2024); *see also* Richard W. Bohannon et al., *Handgrip* *strength: a comparison of values obtained from the NHANES and NIH toolbox studies*, 73(2) Am. J. Occ. Therapy 1, 4-6 (2019), and 54% greater knee extension torque, J. Alberto Neder et al., *Reference values for concentric knee isokinetic strength and power in nonathletic men and women from 20 to 80 years old*, 29(2) J. Orth. & Sports Phys. Therapy 116, 121 (1999). Sex-based discrepancies in lean muscle mass begin to be established from infancy and persist through childhood to adolescence. Shanlee M. Davis et al., S*ex Differences in Infant Body Composition Emerge in First 5 Months of Life*, 32(11) J. Pediatric Endocrinology & Metabolism 1235 (2019); S. Kirchengast & V. Steiner, *Sexual dimorphism in body composition, weight status and growth in prepubertal school children from rural areas of eastern Austria*, 25(1) Collegium Antropologicum 21 (2001); Alison M. McManus & Neil Armstrong, *Physiology of elite young female athletes*. 56 J. Med. & Sport Sci. 23 (2011).

Using their legs and torso for power generation, men can apply substantially larger forces with their arms and upper body, enabling them to generate more ball velocity through overhead motions, as well as to generate more pushing or punching power. Irineu Loturco et al., *Strength and power qualities are highly associated with punching impact in elite amateur boxers*, 30(1) J. Strength Cond. Res. 109 (2016). In other words, isolated sex-specific differences in muscle strength in one region (even differences that in isolation seem small) combine to generate greater sex-specific differences in more complex sport-specific functions. One study examining moderately trained individuals found that males can generate 162% more punching power than females. Jeremy S. Morris et al., *Sexual dimorphism in human arm power and force:*

*implications for sexual selection on fighting ability*, 223(2) J. Exp. Biol. 1, 4-5 (2020). Thus, multiple small advantages aggregate into larger ones.

**d. Throwing and kicking speed**

One result of the combined effects of these sex-determined differences in skeletal structure is that men are, on average, able to throw objects faster than women. Lombardo, *supra*, at 92; Jerry R. Thomas & Karen E. French, *Gender differences across age in motor performance: a meta-analysis*, 98(2) Psych. Bull. 260 (1985). For instance, in one study, elite female baseball pitchers had maximum pitch velocities that were about 75% of their male peers. The authors attribute this to a sex-specific difference in the ability to generate muscle torque and power. Yungchien Chu et al., *Biomechanical comparison between elite female and male baseball pitchers*, 25 J. Applied Biomechanics 22 (2009). A study showing greater throwing velocity in male versus female handball players attributed it to differences in body size, including height, muscle mass, and arm length. Ronald Van Den Tillaar & Jan M. H. Cabri, *Gender differences in the kinematics and ball velocity of overarm throwing in elite team handball players*, 30(8) J. Sports Sci. 807 (2012).

Significant sex-related difference in throwing ability has been shown to manifest even before puberty, but the difference increases rapidly during and after puberty. Thomas, *supra*, at 266; Lombardo, *supra*, at Table 2; Hilton, *supra*, at 203. Competition records from the USA Track and Field National Youth Outdoor and National Junior Olympic Championships show that the average between sex differences for first through fourth place finishers in shot put, javelin, and long jump were greater than within sex differences in all but the 9-10 year old shot put, and males always achieved the best performances. Brown, *supra*, at 3-5.

The impact of these sex-based differences on injury to women can be illustrated by volleyball. Serve and spike velocity in male volleyball players exceeds that of women by about 29-34%. Benedict Forthomme et al., *Factors correlated with volleyball spike velocity*. 33(10) Am. J. Sports Med. 1513 (2005); Daniel P. Ferris et al., *The relationship between physical and physiological variables and volleyball spiking velocity*, 9(1) J. Strength & Cond. Research 32, 34 (1995) (Table 2); José Manuel Palao & David Valadés, *Normative profiles for serve speed for the training of the serve and reception in volleyball*, The Sport Journal (July 2014). Thus, a volleyball struck by a male and traveling an average 30% faster than one struck by a female will deliver 69% more energy to a head upon impact.

The greater leg strength and jumping ability of men confer a further large advantage in volleyball that is relevant to injury risk. In volleyball, an "attack jump" is a jump to position a player to spike the ball downward over the net against the opposing team. Researchers evaluating elite male volleyball players showed that athletes at the 50th percentile demonstrate an attack jump height that is 50% greater than equivalent female volleyball players, with average differences across all percentiles ranging from 42-80%. Tine Sattler et al., *Vertical jump performance of professional male and female volleyball players: effects of playing position and competition level*, 29(6) J. Strength & Conditioning Res. 1486 (2015). This dramatic difference in jump height means that male players who are competing in female divisions will more often be able to successfully perform a spike, and this will be all the more true considering that the women's net height is seven inches lower than that used in men's volleyball.

Male sex-based advantages in leg strength also lead to greater kick velocity. In comparison with women, men kick balls harder and faster. A study comparing university-level male and female soccer players showed that males have an average foot velocity at ball contact that is 32% greater than females, with an average ball velocity that is 20% greater. Keiko Sakamoto et al., *Comparison of kicking speed between female and male soccer players*, 72 Procedia Engineering 50 (2014). A soccer ball kicked by a male, travelling an average 20% faster than a ball kicked by a female, will deliver 44% more energy on head impact. Greater force-generating capacity will thus increase the risk of an impact injury such as concussion.

**2. Females are more vulnerable to certain types of sports injuries.**

In addition to the greater risk of injury to females when males compete against them, caused by the physiological differences that result in the male body bringing greater weight, speed, and force to the athletic field or court, the female body is more vulnerable than the male body to certain types of injury, even when subject to comparable forces.

This risk appears to extend to the younger age cohorts as well. An analysis of Finnish student athletes from 1987 to 1991, examining over 600,000 person-years of activity exposure, revealed higher injury rates in girls than boys among students under fifteen in soccer, volleyball, judo, and karate. Urho M. Kujala et al., *Acute injuries in soccer, ice hockey, volleyball, basketball, judo, and karate: analysis of national registry data*. 311 BMJ 1465 (1995).

Another study looking specifically at injury rates in over 14,000 middle schoolers over a 20-year period showed that middle school girls sustained higher injury rates, and greater rates of time-loss injury than boys. Glenn Beachy & Mitchel Rauh, *Middle school injuries: a 20-year (1988-2008) multisport evaluation*, 49(4) J. Athl. Train. 493, 498 (2014).

Another study of over 2000 middle school students at nine schools showed injury rates for girls' soccer were nearly double that of boys' soccer. Shane V. Caswell et al., *Epidemiology of sports injuries among middle school students*, 51(4) Br. J. Sports Med. 305 (2017).

Here, we focus on two common sport-related injuries: concussions and ACL injuries.

**a. Concussions**

Sport-related concussion, a common sports injury and one with potentially significant effects, is attributable to linear, angular, or rotational acceleration and deceleration forces that result from impact to the head, or from an impact to the body that results in a whiplash "snap" of the head. *See* Steven Rowson et al., *Biomechanical perspectives on concussion in sport*, 24(3) Sports Med. Arthroscopy Rev. 100 (2016). In the case of a concussive head injury, it is the brain that accelerates or decelerates on impact, colliding with the inner surface of the skull. *See* J.T. Barth et al., *Acceleration-deceleration sport-related concussion: the gravity of it all*, 36(3) J. Athl. Training 253, 255 (2001).

Females are generally more likely than males to suffer concussions in comparable sports, and on average suffer more severe and longer-lasting disability once a concussion does occur. Kimberly G. Harmon et al., *American Medical Society for Sports Medicine* *position statement: concussion in sport*, 47 Br. J. Sports Med. 15 (2013); Kate Berz et al., *Sex-specific differences in the severity of symptoms and recovery rate following sports-related concussion in young athletes*, 41(2) The Physician & Sports Med. 58 (2015); Javier Matias-Soto et al., *Concussion Incidence by Type of Sport: Differences by Sex, Age Groups, Type of Session, and Level of Play An Overview of Systematic Reviews With Meta-analysis*, 54(11) J. Orthopaedic & Sports Phys. Therapy 702 (2024). Between menarche and menopause, females also seem to be at higher risk for post-concussion syndrome than males. Jeffrey J. Bazarian et al., *Sex Differences in Outcome after Mild Traumatic Brain Injury*, 27 J. of Neurotrauma 527, 534-35 (2010); Sarah J. Preiss-Farzanegan et al., *The relationship between gender and postconcussion symptoms after sport-related mild traumatic brain injury*, 1(3) PM&R 245 (2009).

Retrospective studies confirm that women are more susceptible to concussions. A large retrospective study of U.S. high school athletes showed a higher rate of female concussions in soccer (79% higher) and volleyball (0.6 concussions/10,000 exposures, with 485,000 reported exposures, vs. no concussions in the male cohort), as well as basketball (31% higher), and softball/baseball (320% higher). Malika Marar et al., *Epidemiology of concussions among United States high school athletes in 20 sports*, 40(4) Am. J. Sports Med. 747 (2012). A similarly-sized, similarly-designed study comparing concussion rates between NCAA male and female collegiate athletes showed, overall, a concussion rate among females 40% higher than that of males. Higher rates of injury were seen across individual sports as well, including ice hockey (10% higher); soccer (54% higher); basketball (40% higher); and softball/baseball (95% higher). Tracey Covassin et al., *Sex differences in reported concussion injury rates and time loss from participation: an update of the National Collegiate Athletic Association Injury Surveillance Program from 2004-2005 through 2008-2009*, 51(3) J. Ath. Training 189 (2016).

These higher rates are attributable to differing physical characteristics. Anatomically, there are significant sex-based differences in head and neck anatomy, with females exhibiting in the range of 30% to 40% less head-neck segment mass and neck girth, and 49% lower neck isometric strength. This means that when a female athlete's head is subjected to the same load as an analogous male, there will be a greater tendency for head acceleration and resultant injury. Ryan T. Tierney et al., *Gender differences in head-neck segment dynamic stabilization during head acceleration*, 37(2) Med. & Sci. in Sports & Exercise 272, 276-77 (2005). In addition, when the heads of female and male athletes are subjected to identical accelerative forces, there are sex-based differences in neural anatomy and physiology, cerebrovascular organization, and cellular response to concussive stimuli that make females more likely to suffer concussive injury or more severe concussive injury. Neil K. McGroarty et al., *Sport-related concussion in female athletes: a systematic review*, 8(7) Orthopaedic J. Sports Med. 1 (2020).

There is also support for the conclusion that females experience increased susceptibility to concussive injuries before puberty. For example, a 2018 study found elevated post-concussion symptoms in girls across all age ranges studied, including children between the ages of 4 and 8. Linda Ewing-Cobbs et al., *Persistent postconcussion symptoms after injury*, 142(5) Pediatrics e20180939 (2018). A 2017 study of middle school students showed over three times the rate of female vs male concussion in students participating in sex-comparable sports. Zachary Y. Kerr et al., *Concussion rates in U.S. middle school athletes, 2015-16 school year*, 53(6) Am. J. Prev. Med. 914 (2017). Similarly, data regarding the incidence of sport-related concussions in U.S. middle schoolers between 2015 and 2020 shows that girls had more than twice the rate of concussion injury in analyzed sports (baseball/softball, basketball, soccer, and track), as well as statistically greater time loss. S.L. Hacherl et al., *Concussion rates in U.S. middle school athletes from the 2015-16 to 2019-20 school years*, 56(6s) J. Athl. Train. S-21 (2021); S.L. Hacherl et al., *Concussion rates and sports participation time loss in sex-comparable middle school sports*, 36 Arch. Clinical Neuropsychology 650 (2021).

Females also, on average, suffer materially greater cognitive impairment than males when they do suffer a concussion. A study of 2340 high school and collegiate athletes who suffered concussions determined that females had a 170% higher frequency of cognitive impairment following concussions than males. Donna K. Broshek et al., *Sex differences in outcome following sports-related concussion*, 102 J. Neurosurgery 856 (2005).

As it stands, when females compete against each other, they already have higher rates of concussive injury than males. The addition of male athletes into women's contact sports will inevitably increase the risk of concussive injury to girls and women. Because the effects of concussion can be severe and long-lasting, particularly for females, if participation by males in women's contact sports based on gender identity becomes more common, more females will suffer substantial concussive injury and the potential for long-term harm as a result.

**b. Anterior Cruciate Ligament injuries**

The Anterior Cruciate Ligament ("ACL") is a key knee stabilizer that prevents anterior translation of the tibia relative to the femur and also provides rotatory and valgus knee stability. Cindy Y. Lin et al., *Sex differences in common sports injuries*, 10(10) PM&R 1073 (2019). ACL injuries can end sports careers, require surgery, and usually results in early-onset, post-traumatic osteoarthritis, triggering long-term pain and mobility problems later in life. Li-Juan Wang et al., *Post-traumatic osteoarthritis following ACL injury*, 22 Arthritis Res. & Therapy article no. 57 (2020).

The rate of ACL injury is substantially higher among female than male athletes. Teresa E. Flaxman et al., *Sex-related differences in neuromuscular control: implications for injury mechanisms or healthy stabilization strategies?*, J. Ortho. Res. 310 (2014); Julie Agel et al., *Anterior cruciate ligament injury in National Collegiate Athletic Association basketball and soccer: a 13-year review*, 33(4) Am. J. Sports Med. 524 (2005). One meta-analysis of 58 studies reports that female athletes have a 150% relative risk for ACL injury compared with male athletes, with other estimates suggesting as much as a 300% increased risk. Alicia M. Montalvo et al., *"What's my risk of sustaining an ACL injury while playing sports?": a systematic review with meta-analysis*, 53 Br. J. Sports Med. 1003 (2019).

Multiple anatomical and physiological differences between males and females play significant roles in making females more vulnerable to ACL injuries than males. Flaxman, *supra*, at 313-15; Jennifer M. Wolf et al., *Male and female differences in musculoskeletal disease*, 23 J. Am. Acad. Orthop. Surg. 339 (2015). Summarizing the findings of a number of separate studies, one researcher recently cited as anatomical risk factors for ACL injury smaller ligament size, decreased femoral notch width, increased posterior-inferior slope of the lateral tibia plateau, increased knee and generalized laxity, and increased body mass index (BMI). Lin, *supra*, at 5. With the exception of increased BMI, each of these factors is more likely to occur in female than male athletes.

Although non-contact mechanisms are the most common reason for ACL tears in females, tears related to contact are common, with ranges reported across multiple studies of from 20%–36% of all ACL injuries in women. Hirokazu Kobayashi et al., *Mechanisms of the anterior cruciate ligament injury in sports activities: A twenty-year clinical research of 1700 athletes*, 9 J. Sports Science & Med. 669, 672 (2010). Thus, as participation in the female category based on identity rather than biology becomes more common, and as collision forces suffered by girls and women across the knee increase accordingly, the risk for orthopedic injury and in particular ACL tears among impacted girls and women will inevitably rise.

## III. Testosterone suppression will not prevent the harm to female safety in athletics.

Hormonal manipulation of male athletes cannot alter the consequences to female safety. As Dr. Emma Hilton has observed, the fact that there are over 3000 sex-specific differences in skeletal muscle alone makes the hypothesis that sex-linked performance advantages are attributable solely to current circulating testosterone levels improbable at best. Hilton, *supra*, at 200–01. Indeed, next to breast tissue, there is no tissue in the human body with more sex-differentiated genetic expression than skeletal muscle. Moran Gershoni & Shmuel Pietrokovski, *The landscape of sex-differential transcriptome and it's consequent selection in human adults*. 15 BMC Biology article 7 (2017).

Even if active treatment with gender-affirming therapy actually results in full testosterone suppression, which is not a given, Jennifer J. Liang et al., *Testosterone levels achieved by medically treated transgender women in a United States endocrinology clinic cohort*, 24(2) Endocrine Pract. 135 (2018); Emily W. Miro et al., *Testosterone Levels in Transgender Women Undergoing Gender-Affirming Hormone Therapy*, 17 Cureus article 5 (2025), the available evidence strongly indicates that no amount of testosterone suppression can eliminate male physiological advantages relevant to performance and safety. Numerous studies demonstrate that one year (or more) of testosterone suppression does not substantially eliminate male performance advantages, Hilton, *supra*, at 211; D. DeVarona et al., *Briefing book: a request to Congress and the Administration to preserve girls' and women's sport and accommodate transgender athletes*, Women's Sports Policy Working Group (2021); Joanna Harper et al., *How does hormone transition in transgender women change body composition, muscle strength and haemoglobin? Systematic review with a focus on the implications for sport participation*, 55(15) Br. J. Sports Med. 865 (2021), and it has been reported that nearly 10% of males on testosterone suppression regimens develop no discernable changes in body composition at all, Daan M. van Velzen et al., *Variation in sensitivity and rate of change in body composition: steps* *toward individualizing transgender care*, 183(5) Eur. J. Endocrinology 529 (2020).

Focusing on those specific sex-based characteristics of males who have undergone normal sex-determined pubertal skeletal growth and maturation that are relevant to the safety of female athletes, the available science tells us that testosterone suppression does not eliminate the increased risk to females or solve the safety problem. In their recent guidelines, UK Sport determined that, "based upon current evidence, testosterone suppression is unlikely to guarantee fairness between transgender women and natal females in gender-affected sports." UK Sports Councils' Equality Group, *Guidance for Transgender Inclusion in Domestic Sport Guidance* at 7 (2021). They also warned that migration to a scenario where eligibility is determined through case-by-case assessment "is unlikely to be practical nor verifiable for entry into gender-affected sports," in part because "many tests related to sports performance are volitional," and incentives on the part of those tested would align with intentional poor performance. *Id.* at 8.

The research relating to hormonal suppression in transgender athletes speaks very clearly to the fact that males retain a competitive advantage over women that cannot be eliminated through testosterone suppression alone. We briefly summarize some of these retained differences as they relate to sport safety.

**A. Bone density**

Bone mass (which includes both size and density) is maintained over at least two years of testosterone suppression, Naykky Singh-Ospina et al., *Effect of sex steroids on the bone health of transgender individuals: a systematic review and meta-analysis*, 102(11) J. Clin.

Endocrinology & Metabolism 3904 (2017); Tayane Muniz Fighera et al., *Bone mass effects of cross-sex hormone therapy in transgender people: updated systematic review and meta-analysis*. 3(5) J. Endocrine Soc. 943 (2019), and one study found it to be preserved even over a median of 12.5 years of suppression, Adrian G. Ruetsche et al., *Cortical and trabecular bone mineral density in transsexuals after long-term cross-sex hormonal treatment: a cross-sectional study*, 16 Osteoporosis Int'l 791 (2005).

**B. Size, weight, and lean body mass**

Males are, on average, larger and heavier than females. These facts alone mean that males bring more kinetic energy into collisions and lighter females will suffer more abrupt deceleration in collisions with larger bodies, creating heightened injury risk for impacted females. Males also have longer limbs, which allow for greater force generation when throwing. Even when puberty is blocked in advance of hormonal manipulation, males still grow to their predicted male height or nearly so, suggesting that not even standard medical treatment regimens remove this advantage. Lidewij Sophia Boogers et al., *Transgender Girls Grow Tall: Adult Height Is Unaffected by GnRH Analogue and Estradiol Treatment*, 107(9) J. Clin. Endocrinology & Metabolism e3805 (2022); Silvia Ciancia et al., *Early puberty suppression and gender-affirming hormones do not alter final height in transgender adolescents*, 189(3) Eur. J. Endocrinology 396 (2023).

Multiple studies have found that testosterone suppression does not eliminate the male advantage in muscle mass and lean body mass, which together contribute to the greater average male weight. Studies looking at the effect of gender-affirming hormone therapy on lean mass show modest decreases or no statistical change. Ky Ford, et al., *Characterising body composition and bone health in transgender individuals receiving gender-affirming hormone therapy*, 35 J. Human Nutr. & Diet. 1105 (2022).

- Researchers looking at transitioning adolescents found that the weight of biological male subjects increased rather than decreased after treatment with an antiandrogen testosterone suppressor, with no loss in muscle strength. Lloyd J.W. Tack et al., *Proandrogenic and antiandrogenic progestins in transgender youth: differential effects on body composition and bone metabolism*, 103(6) J. Clin. Endocrinology & Metabolism 2147 (2018).

- Adolescent biological male subjects who were exposed to puberty-halting medications prior to institution of testosterone suppression presented with lean body mass 2.5 standard deviations higher than biological girls and maintained gains of between 1–2 standard deviations at age 22. Maartje Klaver et al., *Early hormonal treatment affects body composition and body shape in young transgender adolescents*, 15(2) J. Sexual Med. 251 (2018).

- Another study that looked at patients who underwent puberty blockade followed by testosterone suppression found that subjects only reduced lean body mass by 5%, remaining 15% higher than females undergoing masculinizing therapy with testosterone. Lidewij Sophia Boogers et al., *Time course of body composition changes in transgender adolescents during puberty suppression and sex hormone treatment*, 109 J. Clin. Endocrinology & Metabolism e1593 (2024).

- In one recent meta-analysis, researchers looking at the musculoskeletal effects of hormonal transition found that even after males had undergone 36 months of therapy, their lean body mass and muscle area remained above those of females. Harper, *supra*, at 1.

- Another study showed that testosterone suppression led to only a 12% total loss of muscle area by the end of thirty-six months. Louis J.G. Gooren et al., *Transsexuals and competitive sports*, 151 Eur. J. Endocrinology 425 (2004).

- More recently, researchers looking at changes in lean body mass over 5-6 years of hormone therapy showed that with feminizing treatment, biological males only reduced their skeletal muscle mass by 7% and exhibited no statistical change in strength. Tommy R. Lundberg et al., *Longitudinal changes in regional fat and muscle composition and cardiometabolic biomarkers over 5 years of hormone therapy in transgender individuals*, 297(2) J. Intern. Med. 156 (2025).

### C. Strength

A large number of studies observe minimal or no reduction in strength in male subjects following testosterone suppression. In one recent meta-analysis, strength loss after twelve months of hormone therapy ranged from negligible to 7%. Harper, *supra*, at 5. Given the baseline male strength advantage in various muscle groups of from approximately 25% to 100% above female levels, even a 7% reduction will leave a large retained advantage in strength. Handgrip strength is a proxy for general strength, but also a covariate of lower body strength and impulsive activity (such as sprinting or jumping), as well as predictive to some degree of overhead throwing velocity, judo or wrestling success, and boxing ranking. John Cronin et al., *A brief review of handgrip strength and sport performance*, 31(11) J. Str. & Cond. Res. 3187 (2017). One study analyzing handgrip strength showed a 9% loss of strength after two years of hormonal treatment in males who were transitioning, leaving a 23% retained advantage over the female baseline. Hilton, *supra*, at 207. Yet another study, which found a 17% retained grip strength advantage, noted that this placed the median of the group treated with hormone therapy in the 95th percentile for grip strength among age-matched females. Miranda Scharff et al., *Change in grip strength in trans people and its association with lean body mass and bone density*, 8 Endocrine Connections 1020 (2019). Researchers looking at transitioning adolescents showed no loss of grip strength after hormone treatment. Tack, *supra*, at 2151.

Two studies of transitioning Air Force service members had similar results. One recent study of male Air Force service members undergoing transition showed that they retained more than two-thirds of pretreatment performance advantage over females in sit-ups and push-ups after between one and two years of testosterone-reducing hormonal treatment. Timothy A. Roberts et al., *Effect of gender affirming hormones on athletic performance in transwomen and transmen: implications for sporting organizations and legislators*, 55 Br. J. Sports Med. 577 (2020). A similar study in 2022 looking at 228 biologically male, transitioning Air Force personnel showed that these individuals retained statistical advantage over females up to four years for sit-ups, and indefinitely for push-ups, despite the fact that this group started gender-affirming hormone treatment underperforming to males in push-ups at baseline. Maj Elvira Chiccarelli et al., *Fit* *transitioning: When can transgender airmen fitness test in their affirmed gender?* 188 Mil Med. e1588 (2022).

Other studies provide similar conclusions. An observational cohort study looked at thigh strength and thigh muscle cross-sectional area in men undergoing hormonal transition to transgender females. After one year of hormonal suppression, this group saw only a 4% decrease in thigh muscle cross-sectional area, and a negligible decrease in thigh muscle strength. Anna Wiik et al., *Muscle strength, size, and composition following 12 months of gender-affirming treatment in transgender individuals*, 105(3) J. Clin. Endocrinology & Metabolism e805 (2020). The isokinetic strength measurements in individuals who had undergone at least 12 months of hormonal transition showed that muscle strength was comparable to baseline, and torque-generating ability actually increased, leaving transitioned males with a 50% strength advantage over reference females. *Id.* One cross-sectional study that compared men who had undergone transition at least three years prior to analysis, to age-matched, healthy males found that the transgender individuals had retained enough strength that they were still outside normative values for women. This imbalance continued to hold even after eight years of hormone suppression. Bruno Lapauw et al., *Body composition, volumetric and areal bone parameters in male-to-female transsexual persons*, 43 Bone 1016 (2008).

What is more, studies show that strength training can counteract and reduce the limited loss of muscle mass and strength due to testosterone blockade. Thue Kvorning et al., *Suppression of endogenous testosterone production attenuates the response to strength training: a randomized, placebo-controlled, and* *blinded intervention study*, 291 Am. J. Physiol. Endocrinol Metabolism e1325 (2006); Prue Cormie et al., *Can supervised exercise prevent treatment toxicity in patients with prostate cancer initiating androgen-deprivation therapy: a randomized controlled trial*, 115 BJU Int'l 256 (2015).

There is also growing evidence of a muscle memory phenomenon, whereby biological males who have undergone male puberty continue to exhibit a male phenotype for muscle form and function, even when undergoing hormonal therapy in an attempt to achieve a female body type. Biologically male muscle develops with more fast-twitch type II fibers, and a different myonuclear architecture that makes it easier to reacquire muscle mass and strength upon resumption of resistance training. This greater capacity for functional regain seems to exist independent of male levels of testosterone once male muscle epigenetics have been established. Michael Joyner et al., *Evidence on sex differences in sports performance*, 138 J. Appl. Physiol. 274 (2025).

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

**D. Speed**

As to speed, the study of transitioning Air Force members found that these males retained a 9% running speed advantage over the female control group after one year of testosterone suppression, and their average speed had not declined significantly further by the end of the 2.5-year study period. Roberts, *supra*, at

579-81. Again, greater male speed, particularly in combination with the greater male body weight, has negative implications for the safety of females on the field and court.

## CONCLUSION

The Court should hold that the state interest in protecting athlete safety is sufficient to justify banning males from competing in female athletics.

Respectfully submitted.

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