Nos. 24-38, 24-43

IN THE

Supreme Court of the United States

BRADLEY LITTLE, GOVERNOR OF IDAHO, ET AL.,
Petitioners,
v.
LINDSAY HECOX, ET AL.,
Respondents.

WEST VIRGINIA, ET AL.,
Petitioners,
v.
B. P. J., BY HER NEXT FRIEND AND MOTHER, HEATHER JACKSON,
Respondents.

On Writs of Certiorari to the United States Courts of Appeal for the Fourth and Ninth Circuits

BRIEF OF PROFESSORS RICHARD J. AUCHUS, DAVID J. HANDELSMAN, SANDRA K. HUNTER, MICHAEL J. JOYNER, BENJAMIN D. LEVINE, AND VIRGINIA M. MILLER AS *AMICI CURIAE* IN SUPPORT OF NEITHER PETITIONERS NOR RESPONDENTS

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TABLE OF CONTENTS

TABLE OF AUTHORITIES

TABLE OF AUTHORITIES—Continued

TABLE OF AUTHORITIES—Continued

TABLE OF AUTHORITIES—Continued

TABLE OF AUTHORITIES—Continued

TABLE OF AUTHORITIES—Continued

IDENTITY AND INTERESTS OF AMICI[1]

Amici are world renowned biomedical researchers who specialize in the scientific disciplines implicated in these consolidated cases. Their work is highly cited in the top peer reviewed journals of their respective fields, on which domestic and international sport governing bodies rely to develop eligibility rules for female competition. Litigants in domestic courts and international tribunals, including in these cases, also use their work.

Amici take no position on the legal questions presented in this litigation. They seek to participate in their individual professional capacities; they do not speak on behalf of their employers. Their interest is limited to ensuring the record contains clear and correct information on three discrete points of science squarely within their expertise that are relevant to the resolution of those questions:

- The standard biomedical definition and understanding of biological sex.
- The nature of and biological bases for the athletic performance gap between males and females, also known as "male advantage."
- The nature and extent of the mitigating effects of puberty blockers and female gender affirming hormone therapies on the male advantage.

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[1] In accordance with Supreme Court Rule 37.6, no counsel for a party authored this brief in whole or in part, and no persons other than Amici Curiae and their counsel made any monetary contribution intended to fund the preparation and submission of this brief.

The Amici who submit this brief and their fields of expertise are:

Richard Auchus is the James A. Shayman and Andrea S. Kevrick Professor of Translational Medicine in the Division of Metabolism, Endocrinology & Diabetes at the University of Michigan, and Chief of the Endocrinology and Metabolism Section at the Ann Arbor VA Medical Center. Professor Auchus is a steroid biologist who has over 20 years of experience consulting with domestic and international sports organizations. In clinic, he treats both transgender patients and patients with disorders of sex development (DSD). He has authored over 370 journal articles and 40 book chapters and been cited over 20,000 times. He is a member of the Endocrine Society (and prior member of its Board of Directors), the American Heart Association, and the American Association of Clinical Endocrinology. He received the Frontiers in Science & Distinction in Endocrinology Award from the American Association of Clinical Endocrinology in 2023 and was the 2021 recipient of the Outstanding Clinical Investigator Award from the Endocrine Society.

David J Handelsman is Professor of Reproductive Endocrinology and Andrology at the University of Sydney, and Director of the Andrology Laboratory at Concord Hospital in Sydney, Australia. Professor Handelsman is a world-leading authority on androgen physiology, pharmacology, and toxicology arising from his extensive clinical, experimental and public health research over 45 years in elucidating androgen action, use, and misuse. He is currently an associate editor or editorial board member of six journals and ad hoc reviewer for 193 peer-review journals. The author of the major textbook chapters in his field and more than

780 peer-reviewed papers, Professor Handelsman's work has been cited over 48,000 times. Also a longtime consultant to international sports organizations, one of his papers features prominently in this litigation, *Circulating Testosterone as the Hormonal Basis of Sex Differences in Athletic Performance* (2018).

Sandra K. Hunter is the Francie Kraker Goodridge Collegiate Professor of Kinesiology and Chair of Movement Science in the School of Kinesiology at the University of Michigan at Ann Arbor. Professor Hunter's research focuses on human performance with a subspecialty in sex differences in athletic performance. Currently the editor-in-chief of the leading journal in her discipline, Exercise and Sport Sciences Reviews, she has authored 180 papers and book chapters, and her work has been cited over 14,000 times. She has received multiple national awards including from the American Physiological Society (2023) and the American College of Sports Medicine (ACSM; 2025) as an outstanding researcher and scientist. She is lead or co-author on several papers relevant to this litigation including *Sex Differences in Human Performance* (2024) and *Sex-Based Differences in Representation of Top Youth Athletes* (2025).

Michael J. Joyner is the Frank & Shari Caywood Professor of Anesthesiology at the Mayo Clinic College of Medicine and Science. An internationally recognized expert in physiology and sports performance, Professor Joyner's research interests include oxygen transport, exercise, blood pressure, and the role that sex differences play as determinants of physiological responses in humans. He has authored over 640 journal articles and 21 book chapters, and his work has been cited more than 48,000 times. He is lead or co-author on several papers relevant to this litigation

including *Male to Female Transgender Swimmer in College Athletics* (2023) and *Evidence on Sex Differences in Sports Performances* (2025). A fellow of the ACSM, Joyner received an Outstanding Investigator Award from the NIH in 2018 and lifetime achievement awards from the ACSM and the American Physiological Society in 2023.

Benjamin D. Levine is the S. Finley Ewing Jr. Chair for Wellness and the Harry S. Moss Heart Chair for Cardiovascular Research at Texas Health Presbyterian Hospital Dallas, and Distinguished Professor of Exercise Sciences in the Division of Cardiology/Department of Internal Medicine at the University of Texas Southwestern Medical Center. Professor Levine founded and directs the Institute for Exercise and Environmental Medicine which is the largest center in the United States for the study of human physiology and the limits of human performance in health and disease. In his clinical practice Professor Levine sees athletes, including astronauts, from around the world. A Fellow of the ACSM, the American Heart Association, the American College of Cardiology, and the Cardiovascular Section of the American Physiological Society, he serves on the editorial boards of numerous journals. He has published more than 500 peer-reviewed journal articles, reviews, book chapters, and technical papers. His work has been cited over 50,000 times.

Virginia M. Miller is professor emerita of surgery and physiology and former Director of the Women's Health Research Center at the Mayo Clinic in Rochester, Minnesota. A comparative physiologist, Professor Miller's work focused on how sex differences impact health, especially how conditions unique to

women, menopause and pregnancy, impact cardiovascular health. She was president of the Organization for the Study of Sex Differences, director of the Specialized Center of Research Excellence on Sex Differences, and a member of the governing council for the American Physiological Society. The author of key papers on research methodologies for the study of sex differences and more than 500 journal articles and book chapters, Professor Miller's work has been cited over 20,000 times. She has received numerous awards including the Bernadine Healy Award for Visionary Leadership in Women's Health, the Paul M Vanhoutte Distinguished Lectureship in Vascular Pharmacology from the American Society for Pharmacology and Experimental Therapeutics, and the Walter B. Cannon Award from the American Physiological Society.

SUMMARY OF ARGUMENT

Biological sex is the classification of humans as male or female according to their reproductive organs and functions; differences between males and female are caused by different sex chromosomes and concentrations of sex steroids. Biological sex differences in human performance exist from childhood, driven by sex differences in anatomy and physiology. Biological males have male advantage regardless of gender identity and that advantage is only partly mitigated by testosterone suppression and female gender affirming hormone therapy.

ARGUMENT

I. Biological sex is the classification of humans as male or female according to their reproductive organs and functions; differences between males and females are caused by different sex chromosomes and concentrations of sex steroids.

The standard biomedical definition and understanding of sex remains some form of this one, from the Institute of Medicine (now the National Academy of Medicine) in 2001: "The classification of living things, generally as male or female according to their reproductive organs and functions assigned by chromosomal complement." Institute of Medicine, *Exploring the Biological Contributions to Human Health: Does Sex Matter?* 17 (2001). Biological sex is distinct from gender, a psychosocial construct that can be further described in terms of gender roles and expectations, gender expression, and gender identity. Arthur P. Arnold, et al., *Male-female comparisons are powerful in biomedical research*, 629 Nature 37 (May 2024).[2]

[2] Some endocrinologists who work with transgender patients include *gender identity* in their definition of *sex* which they otherwise define as a set of characteristics rather than the body as male or female. See, e.g., *Hecox v. Little*, 104 F.4th 1061, 1068, note 1 (9th Cir. 2023) (citing Joshua D. Safer & Vin Tangpricha, *Care of Transgender Persons*, 381 N. ENG. J. MED. 2451, 2451 (2010)). This choice appears to be based on the characteristics and interests of their particular patient population and on their hypothesis that gender identity is biologically based and related to reproduction. See, e.g., Plaintiff's Opposition to Defendant-Intervenor and Defendant State of West Virginia's Motion to Exclude the Expert Testimony of Dr. Joshua D. Safer at p. 12, *B.P.J. v. West Virginia*, No. 2:21-cv-00316, Doc. 350 (May 26, 2022) (testifying that "the phrase 'biological sex is an imprecise

The chromosomal complement is almost always – i.e. more than 99 percent of the time – either XX (female) or XY (male). Genes on these chromosomes direct development of the gonads and non-gonadal tissue. The differences in the gonads (testes and ovaries) produce sex steroid hormones that mediate further sexual differentiation and development. Together the sex chromosomes and hormones influence human physiology and function beginning in utero and continuing across the lifespan. Thus, "[b]iological sex mean[s] the differences between males and females *caused* by differential sex chromosome complement, reproductive tissues, and concentrations of sex steroids." Gordon Research Conference, *Sex Differences in Immunity in Health and Disease*, April 2-7, 2023 (emphasis added).

Human biological sex is binary, following this clear causal pathway. According to the standard biomedical definition and understanding of sex, variations in the chromosomal complement or in sexual differentiation and development do not create a third sex or a sex spectrum. Rare congenital conditions produce atypical male or female development in specific respects depending on the underlying condition and they are classified accordingly—as either XX or XY disorders of sex development (DSD). For example, 5-Alpha Reductase Deficiency (5-ARD) is a genetic disorder

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term . . . especially in the context of transgender people and people with intersex characteristics [whose] attributes are not always aligned in the same direction"); Joshua D. Safer, *A Current Model of Sex Including All Biological Components of Sexual Reproduction*, 85 L. & CONTEMP. PROBS. 47, 56 (2022) (arguing that "if the word sex is limited to the biology related to sexual reproduction . . . it would include gender identity[.]") Nevertheless, the standard biomedical definition continues to distinguish between *sex* and *gender*, including *gender identity*.

that impairs production of the enzyme required for male external genital development. It is classified as an XY-DSD because it causes clinical manifestations only in biological males—in this case in individuals with an XY chromosomal complement, testes, androgen sensitivity, and testosterone concentrations in the male range.

DSD as a group are exceedingly rare, occurring in approximately 1 in 5,000 live births (0.02 percent). Higher estimates, ranging from two to four percent, have occasionally been reported and used by courts. See, e.g., *Hecox* v. Little, 104 F.4th 1061, 1069 (9th Cir. 2023) (using two percent). Reaching these much higher numbers, however, requires including anatomical variations such as hypospadias – in which the urethral opening on the penis is not at its tip – which experienced clinicians do not classify as DSD. Even when a broader range of conditions is considered, however, experienced clinicians can reliably determine male or female biological sex. Peter A. Lee, et al., *Global Disorders of Sex Development Update since 2006: Perceptions, Approach and Care*, 85 Horm. Res. Paediatr. 158-80 (2016).

Biological sex is pervasive, integrated, and immutable. It is in every cell of the body, established at conception with lifelong functional effects. The work of sex differences researchers is precisely to interrogate the existence, nature, and extent of these effects, tracing how sex-linked characteristics in specific tissues influence organ systems that are themselves integrated throughout the body. Arthur P. Arnold, *Rethinking Sex Determination of Non-Gonadal Tissues*, 134 Curr. Top. Dev. Biol. 289 (2019).

For example, sex differences in cardiovascular disease risk reflect differences in control of heart rate

and constriction of blood vessels (nervous system), development of atherosclerosis (blood vessel structure and lipid metabolism), and pathophysiology of heart failure (cardiac structure). Conditions specific to females, such as preeclampsia of pregnancy or removal of the ovaries prior to menopause can increase a female's risk for hypertension and premature aging, respectively. Chrisandra L. Shufelt et al., *Sex-Specific Physiology and Cardiovascular Disease*, in *Sex Differences in Cardiovascular Physiology, Endocrinology, and Metabolism* 433, 433-54 (Virginia M. Miller & C. Noel Bairey Merz eds., vol. 165, *Adv. Exp. Med. & Biol.*, Springer 2018). Sex differences that are intrinsic or structural in these and other respects cannot be changed; they influence human biology "from womb to tomb." Institute of Medicine, *supra* at 4-5.

Because sex influences our bodies "from womb to tomb", in 2014 the NIH began to require that all federally funded animal research, including on humans, consider sex as a biological variable. Janine A. Clayton & Francis Collins, *Policy: NIH to balance sex in cells and animal studies*, 509 Nature 282, 282-283 (May 2014). The promise of this work to understand sex differences, to grow our basic knowledge of the female body, and to know "the mechanisms of disease as well as the development of novel therapeutics" for males and females is widely recognized. Virginia M. Miller, *Universality of Sex Differences in Cardiovascular Outcomes: Where Do We Go from Here?*, 41 Eur. Heart J. 1697, 1698 (2020).

II. Biological sex differences in human performance exist from childhood, driven by sex differences in anatomy and physiology.

"Contemporary data demonstrate differences between male and female humans and animals in most, if not all, physiological systems, including cardiovascular, musculoskeletal, respiratory and neurological function" which "contribute to sex differences in the physical limits of human motor performance[.]" Sandra K. Hunter & Jonathon W. Senefeld, *Sex differences in human performance*, 17 J. Physiol. 4129, 4130 (2024).

Reflecting the fundamental presence and influence of the sex chromosomes, human sexual development occurs in three phases: in utero, in infancy during "mini puberty," and in adolescent puberty. Mini puberty begins shortly after birth and lasts approximately six months in male infants and about two years, or longer, in female infants. See Julia Rohayem et al., *Mini-Puberty, Physiological and Disordered: Consequences, and Potential for Therapeutic Replacement*, 45 Endocrine Rev. 460, 461-463 (2024) (providing a comprehensive review of the subject to date with a focus on its implications for male sexual development). See also Christoffer H. Renault, *Mini-puberty of Human Infancy – a Window of Opportunity to Evaluate Hypogonadism and Differences of Sex Development?*, 25 Annals of Pediatric Endocrinology & Metabolism 84, 84-85 (2022) (describing mini puberty as an extension of the intrauterine phase "separated . . . by the high concentration of placental hormones at birth").

In all three phases of human sexual development, healthy males have testosterone levels in the adult male range (7.7 nmol/L to 29.4 nmol/L), which are about fifteen to twenty times higher than in healthy females (0 to 1.7nmol/L). David J. Handelsman, A. Hirschberg & Stéphane Bermon, *Circulating Testosterone as the Hormonal Basis of Sex Differences in Athletic Performance*, 39 Endocr. Rev. 803, 806-07 (2018). Except for the period between the end of male mini puberty and the onset of male adolescent puberty, there is no overlap in circulating testosterone concentrations between healthy males and females across the human life span. *Id*. ("circulating testosterone in adults has a strikingly nonoverlapping bimodal distribution with wide and complete separation between men and women").

Androgen receptors, proteins within cells that bind to androgens such as testosterone, are distributed throughout the brain and body. They enable testosterone to exert functional effects in nearly every organ system. Androgen receptors have functional effects beginning in the earliest stages of fetal life.

The role of testosterone as an anabolic (body building) steroid is a central focus in sports science and sports medicine. Testosterone's anabolic properties are also the basis for most doping practices in sport. It is beyond dispute in our specialist communities that testosterone drives the development of skeletal muscle mass (particularly the size of fast-twitch muscle fibers) along with increases in heart muscle mass and red blood cell production, all of which directly enhance human performance. These androgen-dependent adaptations in androgen-sensitive tissues and processes are the principal (but not only)

drivers of sex differences in human athletic performance. They determine muscular power generation (speed and strength), aerobic power (endurance), and fuel utilization, including energy production through glycogen breakdown during high-intensity anaerobic exercise. Benjamin D. Levine et al., Experts Statement on *The Role of Testosterone in Athletic Performance* (2019), https://law.duke.edu/sites/default/files/centers/sportslaw/Experts_T_Statement_2019.pdf.

It is also beyond dispute in our specialist communities that, corresponding to their differing testosterone concentrations through sexual development, males as a group compared with females as a group have:

- more skeletal muscle with a greater number and larger cross-sectional area of fast-twitch fibers, enabling greater strength and power,
- larger and stronger hearts capable of higher stroke volume and cardiac output, contributing to faster and more efficient blood circulation,
- more red blood cells, increasing the blood's oxygen-carrying capacity,
- larger lung size with a greater number of respiratory bronchioles, enhancing oxygen uptake,
- longer and stronger bones that contribute to greater height and mechanical leverage, and
- lower body fat, which can improve relative power and endurance efficiency.

Id. See also Michael J. Joyner, Sandra K. Hunter & Jonathon W. Senefeld, *Evidence on Sex Differences in*

Sports Performance, 138 J. Appl. Physiol. 274, 276-77 (2025); Hunter & Senefeld, *supra* at 4137-4143; Handelsman et al., *Circulating Testosterone*, *supra* at 807, 811-17.[3]

Beyond the virilizing effects of testosterone on the male body, since the NIH issued its 2014 mandate to include females as study participants we have expanded our understanding of female sexual development, anatomy, and physiology. Hunter & Senefeld, *supra* at 4130-4132. Beyond sex differences in the timing,

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[3] The *Hecox* court focused on but misread the Handelman paper. See *Hecox v. Little*, 104 F.4th 1061, 1082 (9th Cir. 2023) (stating that "the Handelsman study . . . actually came to the opposite conclusion, concluding that 'evidence makes it highly likely that the sex difference in *circulating testosterone* of adults explains most, if not all, of the sex differences in sports performance.") (emphasis in opinion). That paper is clear that "circulating testosterone" concentrations are not explanatory on their own; rather, they are important because they are generally responsible for "developing and maintaining masculine characteristics in reproductive tissues . . . and contributing to the anabolic status of nonreproductive body tissues." Handelsman et al., *Circulating Testosterone*, *supra* at 805. Testosterone can produce contemporaneous performance-enhancing effects during exposure – hence the effectiveness of short-term androgen doping – but its maximum impact results from sustained exposure over months and years. A testosterone reading in the male range is thus a proxy, more or less accurate depending on its source, for those physiological adaptations. Conversely, as Amici explain below, "alter[ing]" a transgender woman's testosterone levels "through medical treatment" so that they are in the female range cannot erase some of the important physiological adaptations produced by prolonged exposure to male-range testosterone concentrations, *Hecox, supra* at 1075 (9th Cir. 2023) (quoted text misreading Handelsman to suggest otherwise); on their own, suppressed "circulating testosterone" levels are thus a weak proxy for the physiological adaptations that matter in sports.

duration, and hormonal profiles of mini and adolescent puberty, we now have a better understanding of athletic considerations specific to females. These include the hormonal effects of breast development, which adds weight and places strain on back muscles; differences in pelvic anatomy, which cause a shift in hip position—down and out; and menstrual cycle-associated ligament laxity, which contributes to substantially higher rates and risks of knee and joint injuries in females compared to males. Higher testosterone levels in males are the *primary* driver of the biological sex differences that result in the male advantage in strength, power and endurance; but it is biologically implausible that the anatomy and physiology associated with the presence of two X chromosomes does not also contribute. *Id.* at 4135, 4143; Arthur P. Arnold, *Rethinking Sex Determination of Non-Gonadal tissues*, *supra* at 289; Joyner et al., *supra* at 277.

Early sex differences in sports-relevant tissues and processes are small compared to those that develop during adolescent puberty, but they are nevertheless measurable and significant. Already in infancy, males have more skeletal muscle mass – the tissue most critical for strength and power – than females. *Id.* at 4136; Jonathon W. Senefeld & Sandra K. Hunter, *Hormonal Basis of Biological Sex Differences in Human Athletic Performance*, 165 Endocrinology bqae036 (Mar. 29, 2024) (review article citing papers by others). Male infants also have greater growth velocity and by early childhood – if not sooner – compared to females, males have stronger bones and thicker cartilage. *Id.*

Corresponding to these biological sex differences, as children, males typically run, jump, throw, and engage in rough-and-tumble play more than females. Males outperform females in sports-related tasks both before and after puberty. And from the beginning of organized sports, males as a group consistently outperform females in competition.

Biological sex differences in childhood play, movement, and performance are distinct from any effects of socialization. See *id.* at 275-76; Carole Hooven, *Testosterone: The Story of the Hormone that Dominates and Divides Us* 94-97 (2021) (describing testosterone-based behavioral patterns); *id.* at 99-100 (describing their universality among humans and their commonality among mammalian species); David J. Handelsman, *Sex Differences in Athletic Performance Emerge Coinciding with the Onset of Male Puberty*, 87 Clin. Endocrinol. 68 (2017) (noting the stability of the sex differences over more than three decades). See also Hooven, *supra* at 99 ("the socialization hypothesis" as a complete explanation for early behavioral differences "just doesn't hold up").

Handgrip strength, a physical task widely used as an indicator of overall muscle strength, provides a clear example of early and sustained sex differences and the distinct effects of biology and socialization. A recent systematic review and meta-analysis concluded that, at all ages beginning in early childhood, "boys have greater grip strength than girls." Specifically, "[b]etween 3 and 10 years, female grip strength is approximately 90% of male grip strength. . . . By age 16, female grip strength is 65% of male grip strength. These sex differences have been mostly stable since the 1960s and are similar in magnitude in most countries from which adequate numbers of effects are

available." James Nuzzo, *Sex Differences in Grip Strength from Birth to Age 16*, 25 Eur. J. Sports Sci. e12268 (2025). Systematic review with meta-analysis is considered one of (if not the) the most rigorous forms of scientific evidence.

Building on the handgrip findings, another systematic review with meta-analysis reported significant sex differences in both upper- and lower-limb strength in children. Among 5- to 10-year-olds, boys had 17% greater upper-limb strength and 8% greater lower-limb strength than girls; by ages 14-17, these differences increased to 50% and 30%, respectively. Thus, boys were stronger than girls even before puberty, with the sex difference more pronounced in upper-limb than lower-limb muscles throughout development. These findings are observed in every culture where adequately sized cohorts have been studied. James Nuzzo & Matheus D. Pinto, *Sex Differences in Upper- and Lower-Limb Muscle Strength in Children and Adolescents: A Meta-Analysis*, 25 Eur. J. Sports Sci. e12282 (2025).

Track & field and cross country, the sports at issue in these cases, provide an excellent illustration of these fundamental principles in action. Jumps, throws, and sprints rely primarily on strength and power. Middle-distance running events require a combination of strength, power, and endurance. Long-distance running and walking events rely predominantly on endurance, with strength and power playing key roles in mid-race surges and the finishing kick. Already in the "eight years and under" category, the male advantage is about 3% in the 100 meters, 5% in the 400 meters, 16% in the long jump, and 32.6% in the javelin throw. Among elite adults, the male advantage peaks at 9.8% in the 100 meters, 12% in the

400 meters, and 19.5% in the long jump, with throwing events showing a similar magnitude of advantage despite males using implements that are twice as heavy. Mira A. Atkinson et al., *Sex Differences in Track and Field Elite Youth*, 56 Med. & Sci. in Sports & Exercise 1390 (2024); Gregory A. Brown, Brandon S. Shaw & Ina Shaw, *Sex-based differences in shot put, javelin throw, and long jump in 8-and-under and 9-10-year-old athletes*, 25 Eur. J. Sport Sci. e12241 (2024).

Pre-pubertal performance gaps in the lower ranges from three to five percent have been described as "minimal" or "marginal" compared to their post-pubertal equivalents. See, e.g., Handelsman, *Sex Differences*, *supra* at 69-70; Handelsman, *Circulating Testosterone, supra* at 812. They are nevertheless athletically and competitively significant as margins for winning, placing, and qualifying are often smaller. See, e.g., *id* at 822 (noting that the margin of victory in elite events is often less than one percent).

Ultimately, the effects of the male advantage through childhood are reflected in the combined rankings across age groups which show an incremental decline in the proportion of females in the top ten and top 100 performers. In the youngest age groups, in some but not all events, up to half of the top performers are female. By middle childhood, females consistently represent less than half of the top performers. By age fourteen, females are entirely absent from the top ten and top 100 performers in running and swimming events, with similar patterns in many other sports. Jessica J. James et al., *Sex-Based Differences in Representation of Top Youth Athletes*, Med. & Sci. in Sports & Exercise 1523 (2025).

III. Biological males have male advantage regardless of gender identity and that advantage is only partly mitigated by testosterone suppression and female gender affirming hormone therapy.

Male advantage is inherent in being biologically male. Some individuals may not maximize theirs—for example they may prefer sedentary activities or avoid weight bearing exercise. However, there is no biological reason to think that female gender identity – sans medical intervention – mitigates inherent sports-related advantages tied to male sex.

Female gender affirming hormone therapy in the form of puberty blockers and estrogen supplementation can cause transgender women and girls to experience some degree of performance loss over an extended period depending on their medical regimen, therapeutic compliance, whether they are trained or untrained, and their sport and event.

Puberty blockers, when used to suppress testicular function in biological males, have two known effects relevant to sports performance: they halt the development of secondary sex characteristics from the point treatment begins, and in untrained individuals they increase fat mass relative to skeletal muscle. Puberty blockers do not reverse prior sexual development, including prior bone development.[4] Nor is

[4] The expert testimony in *Hecox* and *B.P.J.* that bone shrinks along with muscle when testosterone is suppressed in transgender women and girls is wrong. *See* Supplemental Declaration of Joshua D. Safer, MD, FACP, FACE, in Support of Plaintiffs' Motion for Preliminary Injunction, *Hecox v. Little*, No. 1:20-cv-184-CWD, Doc. 58-2 at ¶ 17 (June 29, 2020); *B.P.J. v. West Virginia,* Case No. 2:21-cv-00316*,* Plaintiffs' Opposition to Defendant-Intervenor and Defendant State of West Virginia's

there any known physiological or pharmacological basis to suggest that puberty blockers would negate the cumulative effects of pre-blocker training gains or the capacity of trained muscle to retain adaptations through muscle memory.

As a scientific matter, the factual recitations below that there are transgender women and girls "who do *not* have athletic advantages over cisgender female athletes" because their testosterone levels have been suppressed are clearly wrong. *Hecox*, 104 F.4th at 1082 (italics in original); *B.P.J. v. West Virginia State Board of Education*, 98 F.4th 542, 559-61 (4th Cir. 2024) (reciting the erroneous claims that because B.P.J. went on puberty blockers before Tanner stage 2 she "never experienced elevated levels of circulating testosterone" and therefore has "*no* inherent, biologically-based competitive advantages over cisgender girls when participating in sports.") (italics in original). These findings disregard the fact that – unlike girls with complete androgen insensitivity syndrome who are also male – transgender girls experience testosterone-based sexual development in utero and in mini puberty. The findings also

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Motion to Exclude the Expert Testimony of Dr. Joshua D. Safer, Doc. No. 350 (May 26, 2022). Bone mineral density may decline slightly depending on the course of treatment but morphological bone development – i.e. long bone diameter and length which determines limb length and height – is irreversible. See, e.g., 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, 205 (2021). See also Joanna Harper et al., *Longitudinal Performance Changes in Transgender Women Athletes Pre and Post Gender Affirming Hormone Therapy*, 25 EUR. J. SPORTS SCI. e70036 (Sept. 2025) (noting that self-reported height loss in this study was likely inaccurate).

disregard the cumulative benefits of movement and training through childhood that build on that original advantage, as well as the athletic disadvantages associated with female anatomy and physiology – including hip position, the menstrual cycle, and cycle-related ligament issues – that are not conferred by male-to-female gender affirming therapies.

Testosterone suppression and female gender affirming hormone therapy in trained individuals reduce male advantage to different degrees depending on the treatment characteristics – course, duration, and compliance – and the demands of the sport and event. In endurance events, we observe a moderate decrease in male advantage of up to 65%, consistent with the rapid reduction in red blood cell mass and oxygen-carrying capacity of blood to muscles following testosterone suppression. In contrast, in strength- and power-based events, there is only a small decrease of up to 7%, consistent with the persistence of male muscle fiber types, muscle cross-sectional area, and skeletal muscle-to-fat ratio. Based on available data, it is reasonable to assume that about 40% of the male advantage is retained in middle- and long-distance events, and up to 90% is retained in short distance events and strength- and power-based events. See Joyner et al., *supra* at 277-78 (2025) (Statement 6 summarizing the state of the evidence on these points).

The following two cases are illustrative:

The first is a trained male-to-female transgender swimmer from the United States whose best 500-yard freestyle time slowed by only about 5.6%, from 4 minutes 18.72 seconds to 4 minutes 33.24 seconds, after more than two years of testosterone suppression. That event has a well-established sex difference of

about 9%, indicating a retained advantage of approximately 38%. Jonathon W. Senefeld, Sandra K. Hunter, Doriane Coleman & Michael J. Joyner, *Case Studies in Physiology: Male to female transgender swimmer in college athletics*, 134 J. Appl. Physiol. 1032, 1034-1036 (2023). For reference, the 500-yard freestyle is roughly equivalent to 1,829 meters on the track, i.e. it is a mid- to long-distance event.

The second is a trained male to female transgender sprinter from France whose 200-meter time got faster – from 22.95 seconds in 2019 to 22.67 seconds in 2023 – despite at least one year of testosterone suppression. The 200 meters is an event with a well-established sex difference of about 11%.[5]

As a result of their transitions, even as their bodies changed in some respects, both athletes experienced dramatic rank gains, moving from non-elite to elite status when they switched from men's to women's competition. The American swimmer moved from 65th in the collegiate men's division to first in the collegiate

[5] *See* Romain Donneux, *Retour à la Compétition pour Halba Diouf, Athète Transgenre*, L'ÉQUIPE, May 7, 2023. Diouf's best pre-transition 200 meters time came in 2019 and is available on the results site of the Fédération Française D'Athlétisme (Les Bilans), https://www.athle.fr/asp.net/main.html/html.aspx?htmlid=5268 (last visited on Aug. 18, 2025) (using her birth name). That Diouf experienced a performance gain is not unexpected given that the 200 meters is a strength and power event and the athlete had four years of training between the two performances. The gain was smaller than expected, however, and this may reflect some minor effects of testosterone suppression. Amici have not disclosed this athlete's birth name to protect against the social media abuse to which she and her family have been subjected. Nevertheless, if the parties or this Court wish Amici to provide her birth name, Amici request permission to do so under seal.

women's division. The French sprinter moved from approximately 618th in the national men's rankings to third in the national women's rankings.

New research on transgender women athletes continues to clarify specific physical parameters affected by testosterone suppression, reaching complete reversal in the cases of hemoglobin concentrations and red blood cell mass; but it has also consistently reinforced the bottom line that overall male advantage is retained. See, e.g., Joanna M. Harper et al., *Longitudinal Performance Changes in Transgender Women Athletes Pre and Post Gender Affirming Hormone Therapy*, 25 Eur. J. Sports Sci. e70036 (2025) (longitudinal study of ten trained trans women revealing *both* "decrements" in various biological parameters with associated performance loss *and* overall retained advantage); Joanna M. 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 Br. J. Sports Med. 865, 865 (2021) (systematic review concluding that, among other characteristics, "strength may be well preserved in transwomen during the first 3 years of hormone therapy"). In our opinion, there is no biological reason to expect this bottom line to change. Athletic performance depends on multiple sex-related anatomical and physiological parameters acting in concert, many of which cannot be neutralized by hormone therapy. See generally 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, 199, 205-209 (2021) (detailing the biological bases for retained advantages). The scientific evidence is rapidly accumulating in support of longstanding

practical knowledge that training adaptations persist through muscle memory. See, e.g., Nathan Serrano, Esther E. Dupont-Versteegden & Kevin A. Murach, *Muscle Memory Theory: A Critical Evaluation*, 603 J. Physiol. 4705, 4705 (2025) ("the question is not whether muscle memory exists as described . . . but instead, what is the mechanism controlling it?"). And reducing the athletic advantages associated with being male does not remove the athletic disadvantages associated with being female. See Joyner et al, *supra* at 277 (Statement 5 summarizing these disadvantages).

CONCLUSION

Eligibility standards for girls and women's sport are generally derived from a combination of scientific data and analysis and organizational and political goals, including goals that are reflected in anti-discrimination laws. When making decisions related to science, it is important that the science is properly stated.

As a scientific matter, the policy choice to include androgen sensitive biological males in girls' and women's sports undoubtedly introduces male advantage into female competition regardless of an athlete's gender identity or hormone status: male sex is performance enhancing.

Amici recognize that not every sports program has equal representation as a goal. Here equal representation means, for example, providing an equal number of spots on teams, in competitions, on podiums, and in championship positions for biological females as for biological males. Where that is a goal, however, and the sport or event depends to some degree on strength,

power, and/or endurance, as a scientific matter classifying athletes by sex is the only way to ensure it is satisfied.

Respectfully submitted,

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