EXHIBIT 4

WILENCHIK & BARTNESS
A PROFESSIONAL CORPORATION

Jane Doe, by her next friends and parents, Helen Doe and James Doe;
and Megan Roe, by her next friends and parents, Kate Roe and Robert Roe

.v.

Thomas C. Horne, in his official capacity as State Superintendent of Public Instruction;
Laura Toenjes, in her official capacity as Superintendent of Kyrene School District;
Kyrene School District;
The Gregory School;
Arizona Interscholastic Association, Inc.

Case 4:23-cv-00185-JGZ

Expert witness statement
Emma Hilton, PhD

1. Qualifications and experience

1.1. I am Emma Hilton. I am a postdoctoral researcher in developmental biology—the study of how embryos grow and how individuals mature—at the University of Manchester, UK, a world top 50 university.[1] My short-form academic curriculum vitae is attached in **Appendix 1**.

1.2. In 1999, I received my Bachelor of Science degree from the University of Warwick, UK, where I studied Biochemistry. My final year dissertation described research to identify a genetic cause of Sotos syndrome, a genetic disorder characterised by, among other features, prenatal and childhood bone overgrowth, leading to unusually-early peak height velocity, increased stature during childhood, and concurrent advanced bone age.[2] In 2004, I received my Doctor of Philosophy degree from the University of Warwick, UK, having identified a gene regulatory mechanism that integrates molecular growth signals to specify the future tissue development of a particular region of the very early "ball-of-cells" stage vertebrate embryo.[3,4]

1.3. Since 2004, I have been employed as a developmental biologist at the University of Manchester, UK. My developmental biology career has focussed on the molecular mechanisms underpinning inherited genetic disorders in humans, including—but not limited to—those that differently affect males and females and those that affect neuromuscular development during embryo development.[5] I am currently employed in a research programme to uncover the molecular development of the skin surface in tadpoles, which is the animal model I have systematically exploited to understand human development and disease.

1.4. I have authored over 20 peer-reviewed publications in developmental biology and genetics journals, and have received over 1300 citations. My h-index is 17.[6] I have contributed a chapter entry to a key medical textbook on genetic disorders.[7] In 2007, I received the honour of being named as an Outstanding Young Investigator by the European Society of Human Genetics for my research on a sex-linked genetic disorder that causes first-trimester death in male fetuses.[8]

1.5. Although not employed in a teaching role, I deliver an annual lecture to undergraduate medical students in genetic disorders, inheritance and the ethics of medical screening. I have previously delivered teaching to ophthalmology Masters students in eye development and genetic disorders of the eye, and to undergraduate dentistry students on craniofacial disorders.

1.6. Developmental biology is not simply the study of specific processes in specific species (for example, as part of my current collaborative research, how a nerve makes a junction with a developing block of muscle to generate a functional movement unit.) The discipline of developmental biology operates on common principles: how regions are zoned; how cells "talk" to each other; how tissues and organs interact in synergistic or exclusive patterns; how such interactions proceed. These common principles apply to

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[1] https://www.manchester.ac.uk/study/experience/reputation/rankings/
[2] https://www.genomicseducation.hee.nhs.uk/genotes/knowledge-hub/sotos-syndrome/
[3] Rex et al., 2002. Multiple interactions between maternally-activated signalling pathways control Xenopus nodal-related genes. Int J Dev Biol 46: 217-226.
[4] Hilton et al., 2003. VegT activation of the early zygotic gene Xnr5 requires lifting of Tcf-mediated repression in the Xenopus blastula. Mech Dev 120(10): 1127-1138.
[5] https://www.research.manchester.ac.uk/portal/emma.hilton.html
[6] https://scholar.google.com/citations?user=A8zI2ggAAAAJ&hl=en
[7] Hilton et al., 2016. "The BCL6 corepressor (BCOR) and oculofaciocardiodental syndrome." In Epstein's Inborn Errors of Development: The Molecular Basis of Clinical Disorders of Morphogenesis. Oxford University Press, Oxford, UK.
[8] https://www.eshg.org/index.php?id=102

multiple events in the global development of all species. A solid understanding of such principles—as I have acquired over my 20-year career—permits any developmental biologist to quickly build a picture of developmental events outside of their specific research programme. The differentiation, development and patterning of the reproductive system and the physical changes induced during maturation are no exception for a trained developmental biologist.

1.7. Over the past six years, I have deepened my academic knowledge of physical sex development in many species, particularly humans. Notably, my active research has always involved extensive sexing and breeding of animals, dissecting reproductive organs like male testes (frogs) and the female uterus (mice), and understanding reproductive issues in my animal colonies (for example, the loss of male sex characteristics with aging in frogs). As part of my previous research in a sex-linked genetic disorder, I have routinely visualised and analysed sex chromosome conformation in mice and humans.[9]

1.8. My expertise in human sex development is increasingly recognised in an academic context. In 2021, I was invited by the editor to publish a letter in the official organ of the Royal Academy of Medicine in Ireland, where I argued that, "*Human sex is an observable, immutable, and important biological classification; it is a fundamental characteristic of our species, foundational to many biology disciplines, and a major differentiator in medical/health outcomes.*"[10] I am the invited lead author of a chapter on human sex development in an academic "primer" textbook to be published in August 2023.[11] Titled "Two sexes", this peer-reviewed chapter describes the evolution trajectory of the two sexes in almost all complex species, the development of sexed anatomy in humans, and common myths regarding the phenomenon of sex. Although not yet published, the chapter text is attached in **Appendix 2**. Since 2022, I have delivered a seminar to undergraduate life sciences students in sex development and the long-term effects of sex hormones on the development of the human body.

1.9. During my school years, I competed in interscholastic and regional competitions in judo, track running, netball, field hockey, cross-country and tennis. As an adult, I have completed two marathons. I currently participate in recreational sports, playing netball in single-sex and mixed-sex leagues, and weightlifting with a personal trainer. I am a sports fan.

1.10. The relevance of developmental biology in sports performance has been typically underestimated, particularly in the context of transgender athletes. A long-standing assumption has been that hormonal intervention is sufficient to secure fairness when transgender women were included in female sports. I and Doctor Tommy Lundberg (Karolinska Institutet, SWE) challenged, for the first time in the academic literature, that assumption. In Hilton and Lundberg (2021),[12] the peer-reviewed academic publication most relevant to this expert statement, we, "*review[ed] how differences in biological characteristics between biological males and females affect sporting performance and assess[ed] whether evidence exists to support the assumption that testosterone suppression in transgender women removes the male performance advantage and thus delivers fair and safe competition.*" We concluded that, *"[T]he muscular advantage*

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[9] For example, Hilton et al. 2009. BCOR analysis in patients with OFCD and Lenz microphthalmia syndromes, mental retardation with ocular anomalies, and cardiac laterality defects. Eur J Hum Genet 17: 1325–1335.
[10] Hilton et al., 2021. The reality of sex. Ir J Med Sci 190: 1647.
[11] Hilton and Wright, 2023. "Two sexes." In Sex and Gender: A Contemporary Reader. Routledge, Oxford, UK.
[12] Hilton and Lundberg, 2021. Transgender Women in the Female Category of Sport: Perspectives on Testosterone Suppression and Performance Advantage. Sports Medicine 51: 199–214.

enjoyed by transgender women is only minimally reduced when testosterone is suppressed."

1.11. In terms of impact (26th June 2023), we published our review in Sports Medicine, an international leader in sports and exercise medicine research, with a five-year impact factor of 13.671.[13] Our Altmetric score is 5471, and our review is ranked 662 out of 23.9 million academic articles published across all fields.[14] It has already been cited 65 times in the academic literature,[14] and also in scientific media including Nature.[15] Hilton and Lundberg (2021) has been cited in the transgender athlete policies of British Triathlon,[16] British Cycling[17] and World Rugby[18] (which was used to formulate the transgender policies of England Rugby, Scottish Rugby and Welsh Rugby), and cited in the scientific reviews underpinning the policies of Union Cycliste Internationale[19] and World Athletics.[20] It was also cited by the UK Sports Council Equality Group in their influential policy document that highlighted the clash between fairness for female athletes and inclusion of transgender women athletes.[21] In 2022, Hilton and Lundberg (2021) was cited in the US Court of Appeals for the 11th Circuit, by Justice Lagoa in her specially concurring opinion in Adams .v. School Board of St. Johns County, Florida.[22] Also in 2022, we were cited in a literature review on transgender athletes, published by the UK Parliamentary Office of Science and Technology, intended to brief UK Members of Parliament on topical issues.[23] Finally, Hilton and Lundberg (2021) is cited in the findings of the Fifty-fifth Legislature of the State of Arizona in Senate Bill 1165 (SB1165; the legislation relevant to this case).

1.12. In 2021, I was invited to author a policy review by the Canadian Macdonald-Laurier Institute.[24] This policy document is a review of the individual authors' peer-reviewed publications and expert knowledge; it was not itself peer-reviewed by the academic community. In this policy document, we review the importance of sex categories in sport, synthesising knowledge across developmental biology, the physiology of transgender women, and sports philosophy. We conclude that a female category that excludes all males, regardless of gender identity, is philosophically coherent in terms of category definition and necessary to ensure everyone can compete fairly and fully. We argue it is reasonable for female athletes to expect that their rights will be upheld by the institutions and procedures of their sports.

1.13. I have been asked to consult with various UK and international sporting bodies seeking advice on policy formation. Many such meetings have been held under conditions of anonymity. In February 2020, I was invited, alongside world experts in transgender endocrinology, sports science and ethics, by World Rugby to give evidence to the

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[13] https://www.springer.com/journal/40279
[14] https://link.altmetric.com/details/95647691
[15] Photopoulos, 2021. The future of sex in elite sport. Nature 592: S12-15.
[16] https://www.britishtriathlon.org/britain/documents/about/edi/transgender-policy-effective-from-01-jan-2023.pdf
[17] https://www.britishcycling.org.uk/zuvvi/media/Transgender_and_Non-Binary_Policy_-_FAQs.pdf
[18] https://www.world.rugby/the-game/player-welfare/guidelines/transgender/faqs
[19] https://assets.ctfassets.net/761l7gh5x5an/4gHOE5EpVItQux9kf39XYC/5c52616af086bdf2c9731679f213c1cd/The_current_knowledge_on_the_effects_of_gender-affirming_treatment_on_the_markers_of_performance_in_transgender_female_cycli.pdf
[20] Not publicly available.
[21] https://www.uksport.gov.uk/news/2021/09/30/transgender-inclusion-in-domestic-sport; Sports Council Equality Group Guidance for Transgender Inclusion in Domestic Sport, 2021.
[22] https://aboutblaw.com/6fe
[23] https://researchbriefings.files.parliament.uk/documents/POST-PN-0683/POST-PN-0683.pdf
[24] Pike, Hilton and Howe, 2021. Fair Game: Biology, Fairness and Transgender Athletes in Women's Sport. Macdonald-Laurier Institute, Canada.

Transgender Working Group, which was tasked with reviewing their regulations for inclusion of transgender women in female categories in elite international competition.[25] After an extensive, 'mock courtroom/adversarial' consultation process, World Rugby determined that female categories can only be safe and fair if males, regardless of gender identity, are excluded from female categories. During 2021, I was consulted as part of a policy project by the UK Sports Council Equality Group.[26] In July 2022, I was invited to present to the Equality, Diversity and Inclusion Commission of World Triathlon, who subsequently tightened restrictions on transgender women athletes in the female category.[27]

1.14. In December 2021, I participated in an online academic seminar hosted by Sports Resolutions, alongside David Grevemberg, the managing director of the Commonwealth Games Federation.[28] In April 2022, I was invited to speak at the Canadian Academy of Sport and Exercise Medicine 2022 Annual Conference, on the topic of transgender athletes, fairness and eligibility.[29] In November 2022, I was invited to speak at the Royal Academy of Medicine (UK), alongside Richard Budgett, the medical director of the International Olympic Committee.[30] In March 2023, I was invited to speak at the 19th World Congress of the International Academy of Human Reproduction, on the topic of transgender athletes in sports.[31]

1.15. Beyond academic activities, I am a vocal advocate for fairness in female sport, and have presented my research findings and arguments in various formats. In January 2021, I was appointed as a board member of Sex Matters, a UK-based human rights group who lobby for clarity on the protected characteristic of sex in law and in institutions.[32] Examples of my outputs for Sex Matters include formal responses to sports policy consultations.[33] I offer advice and input to other resources produced by employees. I vote on board-level decisions regarding strategy, expenditure, employment decisions and other typical administrative duties. My position with Sex Matters is unpaid and my work is voluntary. I receive compensation for travel, food and accommodation at meetings and events.

1.16. Other examples of advocacy include the first presentation of my research findings and arguments in July 2019 at an event organised by two feminist groups, A Woman's Place UK and FairPlay For Women.[34] In this presentation, I mapped the timeline of policy development by the International Olympic Committee (IOC) with the concurrent scientific data. I was—and remain—strongly critical of the IOC policy development trajectory. In April 2022, I was invited to speak at a private meeting at the UK House of Lords (for which I was compensated for travel costs), and wrote a house-wide briefing pack. I have been invited to consult with athlete groups like the US-based Women's Sports Policy

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[25] https://www.world.rugby/news/563437/landmark-world-rugby-transgender-workshop-important-step-towards-appropriate-rugby-specific-policy; World Rugby Transgender Guidelines, 2020.
[26] https://www.uksport.gov.uk/news/2021/09/30/transgender-inclusion-in-domestic-sport; Sports Council Equality Group Guidance for Transgender Inclusion in Domestic Sport, 2021.
[27] https://www.triathlon.org/news/article/transgender_policy_process
[28] https://www.youtube.com/watch?v=TbE9aEo8ypA
[29] https://casem-acmse.org/wp-content/uploads/2020/02/ENG_CASEM-AQMSE-Quebec-2022-CASEM-AQMSE-1.pdf
[30] https://www.mededucare.com/_files/ugd/70d91e_b49fb63fc9574bac9ce9c34bfac298a9.pdf
[31] https://hr2023.humanrepacademy.org/scientific-program/
[32] https://sex-matters.org/about/emma-hilton-phd/
[33] For example: https://sex-matters.org/wp-content/uploads/2021/05/Sex-Matters-British-Cycling-policy-response.pdf
[34] https://www.youtube.com/watch?v=pzg9QtQelR8

Working Group[35] and the Independent Council on Women's Sport (ICONS).[36] For the latter, I presented at their inaugural event in Las Vegas in June 2022, and I am due to present again in Denver in July 2023. I received compensation for travel, food and accommodation at the inaugural ICONS event.

1.17. I have been interviewed in the UK media on several occasions, including on BBC Radio 4 and BBC Radio 5 Live Sport. I have published opinion pieces in the mainstream media, including the Wall Street Journal (on the harms arising from denial of the biological reality of sex).[37] Most recently, I wrote with Professor David Handelsman, an international expert in the pharmacology of androgens and expert witness for World Athletics.[38]

1.18. I have been asked by the legal team for the Arizona Superintendent of Public Instruction to provide my expert scientific opinion on the need for a protected female sports category, and the loss of fairness for female athletes arising from the inclusion of transgender girls and transgender women in competitive school sports. In preparation for this case, I have read Senate Bill 1165 (SB1165). My understanding of SB1165 is that sports teams within public schools (or in schools engaged in competitive sports against public schools) will be designated by sex as male or female, or designated as mixed-sex. Female-designated teams will exclude male athletes. An effect of SB1165 is the exclusion of transgender girls from teams designated as female-only. I understand that transgender girls are free to participate in male-designated and mixed-sex teams.

1.19. I am currently retained to provide expert scientific opinion for the State of Indiana and the State of Utah. There is no conflict of interest to declare.

1.20. The opinions put forward in this statement are my own, grounded in my education and scientific expertise, and do not necessarily reflect those of my employer, the University of Manchester, UK. I will make no personal, social, sporting or academic gains from the opinion I present here.

1.21. I am being compensated for my time researching and preparing this report at a rate of $400 USD per hour. I will be compensated for deposition at a rate of $450 USD per hour. My compensation does not depend on the outcome of this litigation.

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[35] https://womenssportspolicy.org/
[36] https://www.iconswomen.com
[37] https://www.wsj.com/articles/the-dangerous-denial-of-sex-11581638089
[38] https://amp.theaustralian.com.au/sport/what-science-tells-us-about-transgender-women-athletes/news-story/cb8b7a30f68745a3fa65442b7ff15694

2. Summary of expert witness statement

2.1. Male development, driven by both genetics and hormones, delivers structural differences (compared with females) from as early as first trimester gestation. Physical differences between males and females that matter for athletic sports are detectable in utero, during childhood, and then cemented during puberty.

2.2. Male athletic advantage over female peers in adolescence and adulthood is undisputed. In childhood, male athletic advantage over female peers is evident across track and field events from 8 years old onwards Males systematically outperform their female peers from 8 years old at a frequency that is vanishingly unlikely to result by chance.

2.3. Protected female sports categories are justified to protect fairness (and, discipline-dependent, safety) for female athletes, who, by virtue of typical female development, do not benefit from male development and thus male athletic advantage. This includes protected categories for young female athletes.

2.4. The suppression of testosterone post-puberty in transgender women does not appear to affect skeletal proportions and reduces acquired muscle mass by only a modest amount. The sparse evidence regarding musculoskeletal metrics in transgender girls who have blocked or partially-blocked puberty reveals metrics like height far exceeding those of typical females.

2.5. It is my professional opinion that the State of Arizona is justified in protecting fairness for female athletes in interscholastic sports competition by restricting from those female categories transgender girls and transgender women, because those individuals will have acquired male athletic advantage by virtue of biological development, and acquisition of male athletic advantage is not entirely removed by either puberty blockers and/or testosterone suppression post-puberty.

3. Sex and gender identity

3.1. Sex is an evolved system function common to almost all complex life on earth. Across the natural world, the words "male" and "female" pertain to the two specific reproductive functions within a system of sexual reproduction that proceeds via two differently-specialised gamete types. They are words used to describe cells, tissues, organs and/or entire individuals that have a physical role in the contribution of small gametes (like sperm) or large gametes (like ova), respectively, to the next generation. "Male" and "female" describe the biology of reproduction and I use these words as neutral descriptions of reproductive biology.

3.2. In humans (and indeed, in almost all animals and many plants), the two reproductive functions are divided between two classes of individual, with each class possessing a distinct and specialised molecular and anatomical pattern corresponding to one of the two reproductive functions. In humans, there are two sexes.

3.3. During embryonic development in utero, males and females develop sex-specific primary sex characteristics that have evolved to facilitate function during future reproduction. In humans, healthy male anatomy comprises gonads in the form of external testes (also called testicles) that will make sperm, internal genital structures like the vas deferens (that carries sperm from the testicles to penis) and external genitalia in the form of a penis and scrotum. In contrast, healthy female anatomy comprises gonads in the form of internal ovaries that will make eggs, internal genital structures like a uterus and vagina, and external genitalia in the form of a vulva, incorporating the clitoris.

3.4. The various parts of the reproductive anatomy of a healthy baby (gonad type, internal genitalia, external genitalia) develop as a system in a regulated and coordinated sequence of events. The sex of a baby is routinely and reliably learned or observed—not "assigned", which implies an element of choice or arbitrariness—at birth by visual and palpable[39] assessment of external genitalia, which is a highly-sensitive marker for the whole system.

3.5. The above descriptions of primary sex are standard, appearing in dictionaries,[40] key biology textbooks,[41] academic publications[42] and medical consensus statements like that issued by the Endocrine Society in 2021.[43] By these standard descriptions of sex, transgender girls and transgender women are biologically male and not biologically female.

3.6. Transgender girls and transgender women feel deep distress and discomfort with their male sex ("gender dysphoria") and claim a sense of identification with the female sex (via "gender identity"). The assertion that "*everyone has a gender identity*" (Shumer declaration, 18) is contradicted by the personal testimonies of people, including myself, who do not experience a gender identity and the delineation of the concept of 'agender', which describes "*identifying as having no gender*" (quoted from Shumer declaration in Flack et al. .v. Wisconsin Department Of Health Services).[44] It appears incoherent to

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[39] "Palpable" means, roughly, "detect by touching". This assessment is typically used to confirm the healthy descent of testes in male babies.
[40] Examples include: Oxford English Dictionary; Merriam-Webster Dictionary.
[41] Examples include: Baresi and Gilbert, 2020. Developmental Biology. Oxford University Press, UK; Wolpert, Tickle and Martinez Arias. Principles of Development. Oxford University Press, UK.
[42] Academic publications defining sex, actively researching sex or incidentally dependent on these understandings of sex are too numerous to consider. For example, a search on the scientific publication database PubMed for only "male [AND] sperm" (that is, not an exhaustive search) retrieves over 100,000 results, including multiple results from Nobel Laureates in Physiology or Medicine, and from a huge array of biology and medical disciplines.
[43] Barghava et al., 2021. Considering Sex as a Biological Variable in Basic and Clinical Studies: An Endocrine Society Scientific Statement. Endocrine Reviews, 42(3): 219-258.
[44] http://files.eqcf.org/wp-content/uploads/2019/04/170-Shumer-Expert-Witness-Report.pdf

argue that everyone has a gender identity while recognising the existence of being 'agender'.

3.7. I am scientifically-neutral to the possibility that "*gender identity has a strong biological basis*" (Shumer declaration, 19 and 22). I do not consider gender identity to be a component of sex, which denotes one's physical reproductive development and reproductive role. Even if it is true that gender identity is in some way biological in basis, gender identity is irrelevant to eligibility for sporting categories based on sex. The premise that, in transgender people, sex "*designation turns out to be inaccurate because it does not reflect the person's gender identity*" (Shumer declaration, 27) creates a contradiction where gender identity is asserted as a feature of sex (Shumer declaration, 26) yet is an identity that exists by reference to one's sex (Shumer declaration, 25, decouples gender identity from "*birth sex*").

3.8. Disorders of sex development (DSDs), where the development of reproductive anatomy is atypical or disrupted,[45] are very rare[46] but frequently used to argue that sex in humans cannot be described as simply male and female. While it is true that, rarely even within DSDs, the sex of some individuals is difficult to classify, this is irrelevant when considering the sex of transgender people, who do not typically have DSDs.

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[45] For example: Arboleda et al., 2014. DSDs: genetics, underlying pathologies and psychosexual differentiation. Nature Reviews Endocrinology 10(10): 603-615.

[46] Sax, 2002. How common is Intersex? A response to Anne Fausto-Sterling. Journal of Sex Research 39 (3): 174-178.

4. Sex and somatic growth

4.1. Beyond differences in reproductive anatomy, males and females differ in somatic (non-reproductive) physical characteristics. Somatic differences first emerge in utero, are evident at birth, and are further cemented during puberty.

4.2. Small differences in average body length (measured as head-bottom length) can be detected by ultrasound from the first trimester of pregnancy, when males are already slightly longer than females.[47] Larger average skull diameter in male fetuses at twenty weeks has been reported.[48] Gestational growth charts track not just higher male values for skull diameter but also higher abdominal circumference and estimated fetal weight.[49] Analysis of growth charts[50] for male and female infants reveals that, at birth, males are, on average, slightly longer and heavier than females.

4.3. In a large study of male and female fetuses and newborns, Broer-Brown et al (2016) concluded that, "Sex affects both fetal as well as infant growth. Besides body size, also body proportions differ between males and females with different growth patterns."[51] Although the magnitude of size differences in utero and at birth are small, they are consistently-different between males and females; indeed, sex is considered necessary to clinically assess fetal growth with accuracy.[52]

4.4. Males are consistently 1-2 cm taller than females between 0-10 years old. Boys at 10 years old also have a larger vertebral cross-sectional area (larger spinal columns) than girls.[53] Girls enter puberty earlier than boys, typically around 10 years old, and the growth spurt associated with earlier pubertal onset accounts for taller female height between 10-14 years old. Boys catch up and overtake girls in height at around 14 years old.

4.5. At puberty, both sexes undergo rapid somatic changes as they mature in preparation for reproduction, leading to measurably different adult body shapes ('sexual dimorphism').[54] Many male secondary sex characteristics are rooted in our evolutionary history of male fighting ability, displays of strength and competition for mates[55] and become increasingly evident as puberty progresses.

4.6. When—briefly—considering sexually-dimorphic physical characteristics in males compared with females, adolescent and adult males are typically taller with wider shoulders, longer limbs and longer digits. They have larger and denser muscle mass, reduced fat mass, different distributions of muscle and fat, and stiffer connective tissue.

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[47] Pedersen, 1980. Ultrasound evidence of sexual difference in fetal size in first trimester. British Medical Journal 281(6250): 1253.

[48] Persson et al., 1978. Impact of fetal and maternal factors on the normal growth of the biparietal diameter. Scandinavian Association of Obstetricians and Gynaecologists 78: 21-27.

[49] Schwartzler et al., 2004. Sex-specific antenatal reference growth charts for uncomplicated singleton pregnancies at 15–40 weeks of gestation. Ultrasound in Obstetrics and Gynaecology 23(1): 23-29.

[50] For example: World Health Organisation https://www.who.int/tools/child-growth-standards/standards; Centre for Disease Control https://www.cdc.gov/growthcharts/clinical_charts.htm; Royal College of Paediatrics and Child Health https://www.rcpch.ac.uk/resources/growth-charts

[51] Broere-Brown et al, 2016. Sex-specific differences in fetal and infant growth patterns: a prospective population-based cohort study. Biology of Sex Differences 7: 65.

[52] Galjaard et al., 2019. Sex differences in fetal growth and immediate birth outcomes in a low-risk Caucasian population. Biology of Sex Differences 10: 48.

[53] Gilsanz et al., 1997. Differential Effect of Gender on the Sizes of the Bones in the Axial and Appendicular Skeletons. Journal of Clinical Endocrinology and Metabolism 82(5): 1603-1607.

[54] For example: Darwin, C. *The Descent of Man, and Selection in Relation to Sex*. London: Murray, 1871; Well, 2007. Sexual dimorphism of body composition. Best Practice and Research Clinical Endocrinology and Metabolism 21(3): 415-430.

[55] For example: Morris et al., 2020. Sexual dimorphism in human arm power and force: implications for sexual selection on fighting ability. Journal Of Experimental Biology 223(2): 212365; Puts, 2010. Beauty and the beast: mechanisms of sexual selection in humans. Evolution And Human Behaviour 31(3): 157-175.

They have higher amounts of haemoglobin (the molecule that carries oxygen in blood), and larger hearts and lungs.[56]

4.7. The above is a non-exhaustive list of sexually-dimorphic differences between males and females, which could number into the thousands, and include, for example, the fine architecture of muscle tissue like proportions of cell type (fibre type, stem cell populations), cell morphology (numbers of nuclei, amounts of myoglobin) and some 3000 muscle-specific gene expression differences,[57] to the minutiae of different visual perception, hand-eye coordination and tracking capacity.[58]

[56] Reviewed in: Hilton and Lundberg, 2021. Transgender Women in the Female Category of Sport: Perspectives on Testosterone Suppression and Performance Advantage. Sports Medicine 51, 199–214 (and references therein).

[57] Haizlip et al., 2014. Sex-Based Differences in Skeletal Muscle Kinetics and Fiber-Type Composition. Physiology (30)1: 30-39.

[58] For example: Mathew et al., 2020. Sex differences in visuomotor tracking. Scientific Reports 10: 11863.

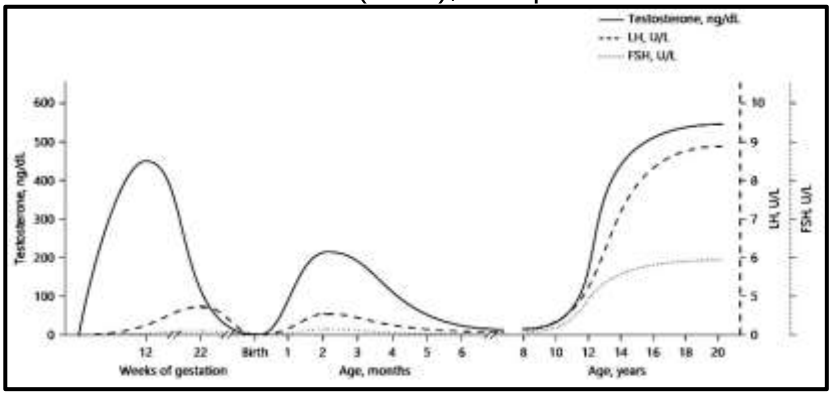
5. Genetics, hormones and development

5.1. Sex differentiation is initiated in utero by the presence or absence of a gene called SRY, typically carried on the Y chromosome, and triggering bipotential gonad development into testes or ovaries in males or females, respectively.[59] The developing gonads, in conjunction with other tissues, establish sex-specific hormonal milieu that, in concert with hormones produced elsewhere, are involved in ongoing male or female physical development.[60]

5.2. It is often assumed that hormones are the driver of all physical sex differences downstream of gonad differentiation.[61] However, analysis of sex-specific genetic architecture in adults reveals some 6500 differences in gene expression, likely to influence development and function outside of hormone effects.[62] Indeed, that "every cell has a sex" dependent on genetics and independent of hormones is recognised and increasingly of scientific interest.[63] REF IOC paper analysis

5.3. A key hormone generating physical differences between males and females is testosterone. Males are exposed to testosterone at three stages of development: 1. in utero; 2. in the post-natal 'minipuberty' period; and, 3. during classic puberty (Figure 1, solid line[64]). Thus, there is an ongoing pattern of differential exposure to testosterone during the development of males and females.

Figure 1. "The three endocrine puberties in boys."
From Becker and Hesse (2020), with permission from S. Karger AG, Basel, CHE



5.4. In utero, testosterone and derived dihydrotestosterone (DHT) are involved in the development of male reproductive anatomy. Testosterone is primarily produced by the male testes.[65] Testosterone promotes the formation of the vas deferens and other male internal genital structures, while DHT is necessary for the development of the penis and prostate gland.[66] The effect of testosterone on somatic development in utero does not appear to be meaningful, and sex differences in fetal size appear unrelated to hormones

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[59] Sekido and Lovell-Badge, 2013. Genetic control of testis development. Sexual Development 7:21-32.
[60] Nussey and Whitehead, 2001. Endocrinology: An Integrated Approach. BIOS Scientific Publishers, Oxford, UK.
[61] Lovell-Badge, 1993. Sex determining gene expression during embryogenesis. Philosophical Transactions of The Royal Society (Biological Sciences) 339: 159-164.
[62] Gershoni and Pietrokovski, 2017. The landscape of sex-differential transcriptome and its consequent selection in human adults. BMC Biology 15(1): 7.
[63] For example: Shah et al., 2014. Do you know the sex of your cells? American Journal of Physiology (Cell Physiology) 306(1): C3-C18; Ainsworth, 2017. Sex and the single cell. Nature 550: S6-S8.
[64] Becker and Hesse, 2020. Minipuberty: Why Does it Happen? Hormone Research in Paediatrics 93(2): 76-84.
[65] Richmond and Rogol, 2007. Male pubertal development and the role of androgen therapy. Nature Clinical Practice Endocrinology and Metabolism 3(4): 338-344.
[66] Theakston, 2020. Development of the Reproductive System https://teachmeanatomy.info/the-basics/embryology/reproductive-system

but related rather to the sex-specific genetics of maternal-placental interactions with a male fetus, which affect, for example, nutrient exchange.[67]

5.5 In the post-natal minipuberty period between 1 week to 6 months of age, transient activation of the hypothalamic-pituitary-gonadal axis means males are exposed to a corresponding burst of testosterone.[68] This burst of testosterone supports male penis and testes growth,[69] and is associated with higher growth velocity in the first six months of life,[70] higher weight gain, lower acquisition of body fat and lower body mass index.[71] The transient exposure to testosterone in minipuberty is an excellent candidate to explain the well-established structural differences between males and females in childhood described in **Section 4**.

5.6 At puberty, males experience levels of testosterone up to 20 times greater than in females, driving development during the ensuing teenage years of male secondary sex characteristics.[72] The effects of testosterone on male somatic growth during puberty are well-characterised and hardly require repeating here.[73]

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[67] Buckberry et al., 2014. Integrative transcriptome meta-analysis reveals widespread sex-biased gene expression at the human fetal–maternal interface. Molecular Human Reproduction 20(8): 810-819.
[68] Lanciotti et al., 2018. Up-To-Date Review About Minipuberty and Overview on Hypothalamic-Pituitary-Gonadal Axis Activation in Fetal and Neonatal Life. Frontiers in Endocrinology 9: 410.
[69] Boas et al., 2006. Postnatal penile length and growth rate correlate to serum testosterone levels: a longitudinal study of 1962 normal boys. European Journal of Endocrinology 154(1): 125-129.
[70] Kiviranta et al., 2016. Transient Postnatal Gonadal Activation and Growth Velocity in Infancy. Pediatrics 138(1): e20153561.
[71] Becker et al., 2015. Hormonal 'minipuberty' influences the somatic development of boys but not of girls up to the age of 6 years. Clinical Endocrinology 83: 694-701.
[72] Handelsman et al., 2018. Circulating Testosterone as the Hormonal Basis of Sex Differences in Athletic Performance. Endocrine Reviews 39(5): 803-829.
[73] Reviewed in, for example: Hiort, 2002. Androgens and puberty. Best Practice and Research Clinical Endocrinology and Metabolism 16(1): 31-41; Richmond and Rogol, 2007. Male pubertal development and the role of androgen therapy. Nature Clinical Practice Endocrinology and Metabolism 3(4): 338-344.

6 Sex and sporting advantage in adolescence and adulthood

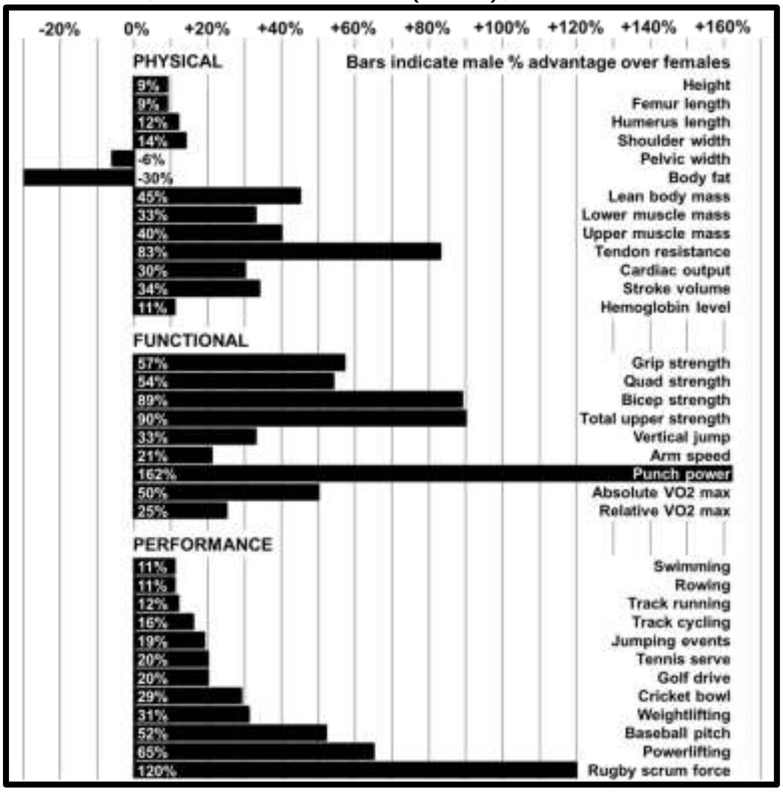
6.1 In most athletic sports—those where outcome is affected by speed, stamina, strength and physique—males have a class-level advantage over females. Male advantage is founded in the physical differences, acquired during male development, that underpin functional differences in muscular strength, skeletal levers and proportions, force application, upper to lower body strength, and cardiovascular and respiratory function. In turn, these functional differences confer superior athleticism.[74]

6.2 Examination of sporting records and performances identifies few athletic sporting disciplines where males do not possess performance advantage over females[75], and competitions are typically separated by sex. Volleyball, basketball, soccer and cross-country running are among those where male development provides competitive advantage, and where competitions are therefore separated by sex.

6.3 The physical, functional and performance advantages in adult males are summarised in Figure 2, using reported record performances across multiple sports and sporting actions. Male strength is disproportionately large in the upper body, and sports and sporting movements that require upper body input typically exhibit larger performance gaps than that where lower body strength is key. Performance differences, emerging from the physical and functional differences between adult males and females, have been described as “insurmountable”.[76]

Figure 2. Physical, functional and performance differences between males and females.

From Pike, Hilton and Howe (2021); data from Hilton and Lundberg (2021)



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[74] For example: Tonnessen et al., 2015. Performance development in adolescent track and field athletes according to age, sex and sport discipline. PLOS One 10(6): e0129014.

[75] For example: Olympic performances https://olympics.com/en/olympic-games/olympic-results; track and field performances https://www.worldathletics.org/stats-zone

[76] Thibault et al., 2010. Women and Men in Sport Performance: The Gender Gap has not Evolved since 1983. Journal of Sports Science and Medicine 9(2): 214-223.

6.4 The significance of male puberty is evidenced by the fact that male performances typically exceed those of elite females in mid-puberty; a comparison of elite female records with male junior records[77] is listed in Table 1. Unsurprisingly, in events like the marathon that are associated with greater strategy and maturity, males are older when they surpass elite female records.

Table 1. Elite female records are surpassed by males in mid-puberty.
Abbreviations: m – metres, km – kilometres, s – seconds, m – minutes, h – hours, yrs – years old

Event	Elite female record	Age at which male records surpass elite female records
100 m	10.49 s	15 yrs (10.20 s)
200 m	21.34 s	14 yrs (20.89 s)
400 m	47.60 s	14 yrs (46.96 s)
800 m	1 m:53.28 s	14 yrs (1 m:51.23 s)
1500 m	3 m:50.07 s	14 yrs (3 m:48.37 s)
5km	14 m:06.62 s	15 yrs (14 m:06.51 s)
10km	29 m:01.03 s	16 yrs (28 m:39.04 s)
Marathon	2 h:17 m:01 s	19 yrs (2 h:11 m:34 s)
High jump	209 cm	14 yrs (217 cm)
Pole vault	506 cm	15 yrs (550 cm)
Long jump	752 cm	15 yrs (785 cm)
Triple jump	1574 cm	15 yrs (1663 cm)
Shot put	2263 cm (4 kg shot)	15 yrs (2386 cm; 5 kg shot)
Discus	7680 cm	15 yrs (7768 cm)
Hammer	8298 cm	14 yrs (8517 cm)
Javelin	7228 cm	14 yrs (7642 cm)

6.5 Importantly, male athletic advantage over females is not limited to those physical and functional differences conferred by male morphology, shape and size. Most obviously, female athletes must typically deal with the effects of the menstrual cycle and the cyclical effects of hormones on training capacity and performance. The menstrual cycle is known to affect cardiovascular, respiratory, brain function, response to ergogenic aids, orthopedics, and metabolic parameters,[78] and represents a barrier to athletic capacity not experienced by males. A third of females report their menstrual flow to be "above average" volume.[79] 37 % of female athletes report heavy menstrual flow, and 90 % report menstrual symptoms, affecting their ability to train and compete.[80]

6.6 Further, injury susceptibility differs between males and females, with subsequent impacts on training time. For example, emerging research shows that compared with males, female rugby players appear more susceptible to concussive injuries, with more severe outcomes. This has been attributed to lower impact resistance in their neck

[77] http://age-records.125mb.com; https://worldathletics.org/records/by-category/world-records
[78] Meignie et al., 2021. The Effects of Menstrual Cycle Phase on Elite Athlete Performance: A Critical and Systematic Review. Frontiers in Physiology 12: 654585.
[79] Bitzer et al., 2013. Women's attitudes towards heavy menstrual bleeding, and their impact on quality of life. Open Access Journal of Contraception 4: 21-8.
[80] Bruinvels et al., 2021. Prevalence and frequency of menstrual cycle symptoms are associated with availability to train and compete: a study of 6812 exercising women recruited using the Strava exercise app. British Journal of Sports Medicine 55: 438-443.

muscles and more delicate brain structures.[81] A study of sex differences in cultured nerve cells has shown that, compared with male neurons, female neurons have a smaller cross-section and contain fewer, less-dense structural “fibres”; female neurons are more easily damaged when subject to stretch trauma, and they exhibit higher injury responses post-trauma.[82] Female athletes have a higher incidence of anterior cruciate ligament injury than males and poorer response to injury-prevention programmes, well-studied in soccer and typically attributed to female lower body anatomy (hip width, muscle ratio, joint flexibility).[83]

[81] www.rugbypass.com/news/long-term-brain-damage-could-be-a-significantly-bigger-issue-in-womens-rugby-than-mens-says-lead-concussion-doctor/
[82] Dollé et al., 2018. Newfound sex differences in axonal structure underlie differential outcomes from in vitro traumatic axonal injury. Exp Neurol 300:121-134.
[83] Crossley et al., 2020. Making football safer for women: a systematic review and meta-analysis of injury prevention programmes in 11 773 female football (soccer) players. British Journal of Sports Medicine 54: 1089-1098.

7 Sex and sporting advantage in childhood

7.1 While few deny the athletic sporting differences between males and females in adolescence and adulthood, sporting performance gaps between the sexes before puberty are less well-characterised.

7.2 In **Section 4**, I outlined known physical differences between males and females in utero and during childhood. At the level of function leading to athletic performance, large cohort studies of fitness data in typical schoolchildren reveals differences evident from as young as 6 years old. In these childhood fitness programs, females consistently outperform males in the sit and reach test, a measure of flexibility. However, males can run 9.8 % faster over short sprints, jump 9.5 % further from a standing start, complete 33 % more push ups in 30 seconds, complete 16.6 % more shuttle runs in a given time and have 13. 8 % higher grip strength.[84] Young males of 6-7 years old have higher absolute (+11 %) and relative (+8 %) VO_{2max} than female peers.[85]

7.3 The Presidential Fitness Test was a US fitness testing program conducted in middle school and high schools until 2013. Awards were given to schoolchildren in the top 15th percentile in their cohort. I calculated the % difference between the top 15th percentile in male and female schoolchildren aged 6-16 years old, listed in Table 2.[86]

Table 2. Male advantage (%) at the top 15th percentile in the US Presidential Fitness Test for schoolchildren.

Abbreviations: yrs – years old, n – number, s – seconds, cm - centimetres

Age	Curl ups n	Shuttle run s	Sit and reach cm	1 mile s	Pull ups n
6 yrs	3.1	2.4	-36.4	9.6	0.0
7 yrs	5.9	5.0	-30.0	11.6	100.0
8 yrs	5.3	5.9	-33.3	12.3	150.0
9 yrs	5.1	1.8	-45.5	10.4	150.0
10 yrs	12.5	4.6	-33.3	14.7	100.0
11 yrs	11.9	4.8	-38.5	16.6	100.0
12 yrs	11.1	5.8	-42.9	14.3	250.0
13 yrs	15.2	6.9	-50.0	16.8	250.0
14 yrs	19.1	9.9	-43.8	19.4	400.0
15 yrs	18.8	10.0	-37.5	22.1	450.0
16 yrs	24.4	13.9	-33.3	26.8	1000.0

7.4 Thus, physical performance differences among schoolchildren are detectable and measurable in school fitness testing programmes. To begin to systematically analyse pre-puberty and early pubertal differences in sports performance between males and females, I interrogated the extensive track and field performance data available in young people. Track and field events comprise the simple "building blocks'—running, jumping and throwing—that are key to athletic performance in many individual and team sports, including volleyball, soccer and basketball. Thus, track and field event performances can be used to understand likely performance differences in more complex sports.

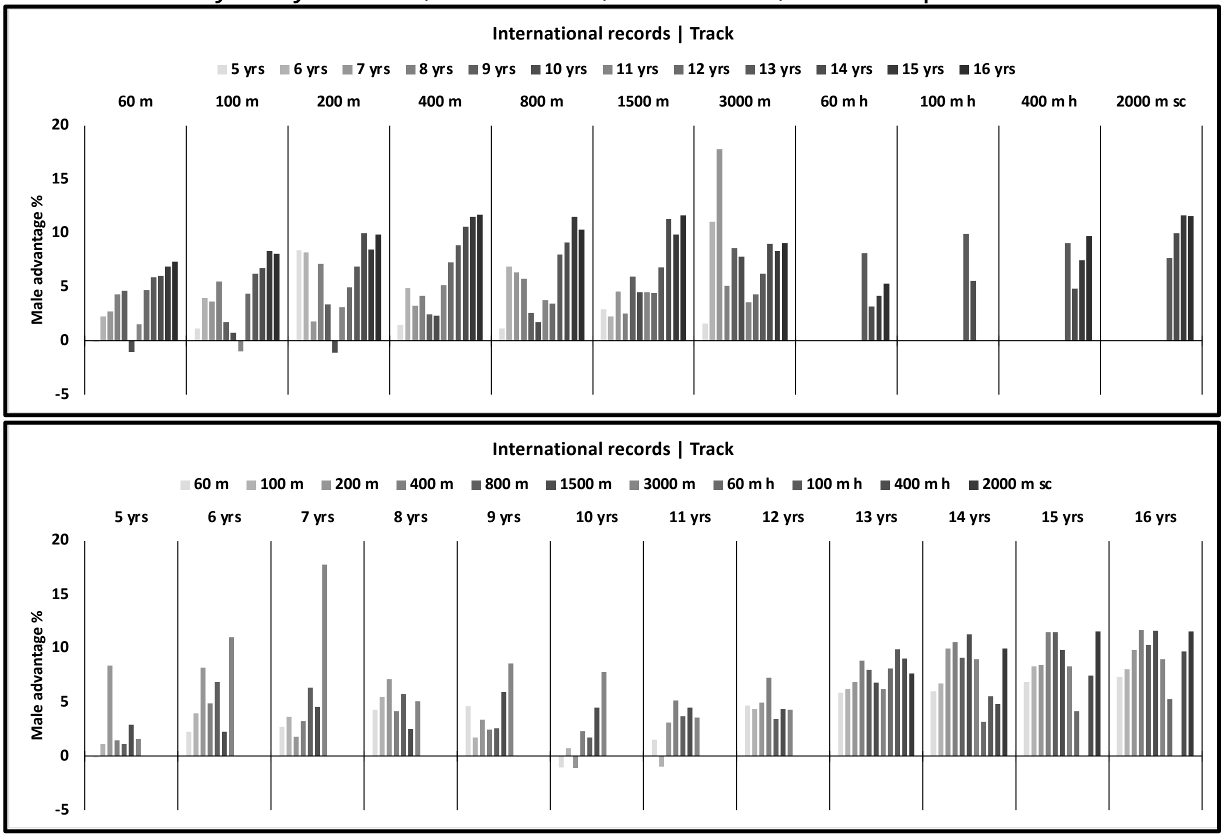
[84] For example: Catley and Tomkinson, 2013. Normative health-related fitness values for children: analysis of 85347 test results on 9–17-year-old Australians since 1985. British Journal of Sports Medicine 47(2): 98–108; Tambalis et al., 2016. Physical fitness normative values for 6–18-year-old Greek boys and girls, using the empirical distribution and the lambda, mu, and sigma statistical method. European Journal of Sport Science 16(6): 736-746.

[85] Eiberg et al., 2005. Maximum oxygen uptake and objectively measured physical activity in Danish children 6–7 years of age: the Copenhagen school child intervention study. British Journal of Sports Medicine 39(10): 725-730.

[86] https://gilmore.gvsd.us/documents/Info/Forms/Teacher%20Forms/Presidentialchallengetest.pdf

7.5 I collected international records in multiple track and field events from both males and females from the ages of 5-16 years old.[87] I then calculated the % difference between the male record and equivalent female record. The male advantages (%) in track, stratified by both event (upper panel) and age (lower panel), are shown in Figure 3. In track events, male advantage is clear in all age groups and for all events.

Figure 3. The male advantage over females in international schoolchildren records in track events, stratified by event (upper panel) and age group (lower panel). Abbreviations: yrs – years old, m – metres, h – hurdles, sc – steeplechase



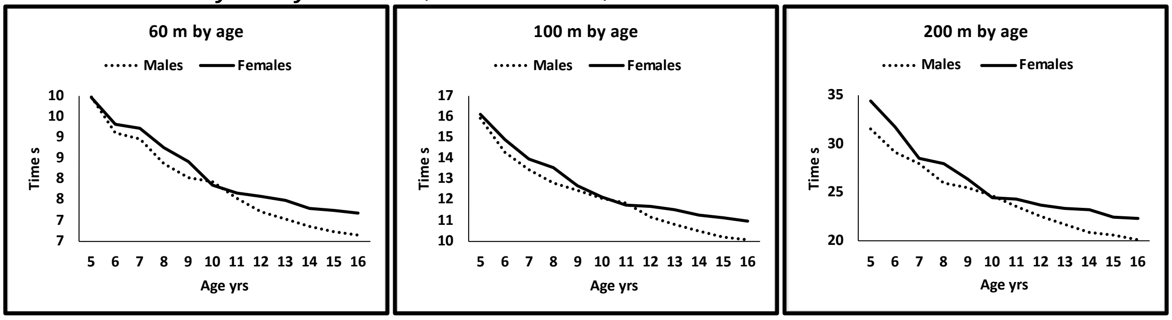
7.6 There are four track events where female schoolchildren appear to outperform their male peers, listed in Table 3. I examined the age progression of these events to seek to understand this apparent female advantage. These data are shown in Figure 4. For 60 m at 5 years old, in the absence of a preceding datapoint, it is impossible to evaluate the female advantage here. For 60 m at 10 years old, the male record appears slightly slower than predicted, with no specific explanation for this beyond typical variation. In this same event, the female record is faster than expected, possibly explained by earlier onset of puberty and associated growth spurt that provides transient 'catch up' with male peers. For 100 m at 11 years old and 200 m at 10 years old, again the female records appear faster than expected, again likely underpinned by pubertal growth spurt in these female athletes.

[87] International age records http://age-records.125mb.com

Table 3. Female advantage in international schoolchildren track records.
Abbreviations: yrs – years old, m – metres

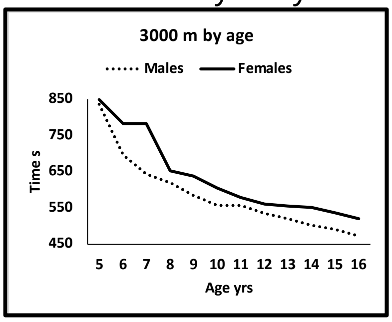
Event	Age group	Female advantage %
60 m	5 yrs	0.1 %
	10 yrs	1.0 %
100 m	11 yrs	0.9 %
200 m	10 yrs	1.1 %

Figure 4. Age progression in the 60 m, 100 m and 200 m sprints in international schoolchildren records.
Abbreviations: yrs – years old, m – metres, s – seconds



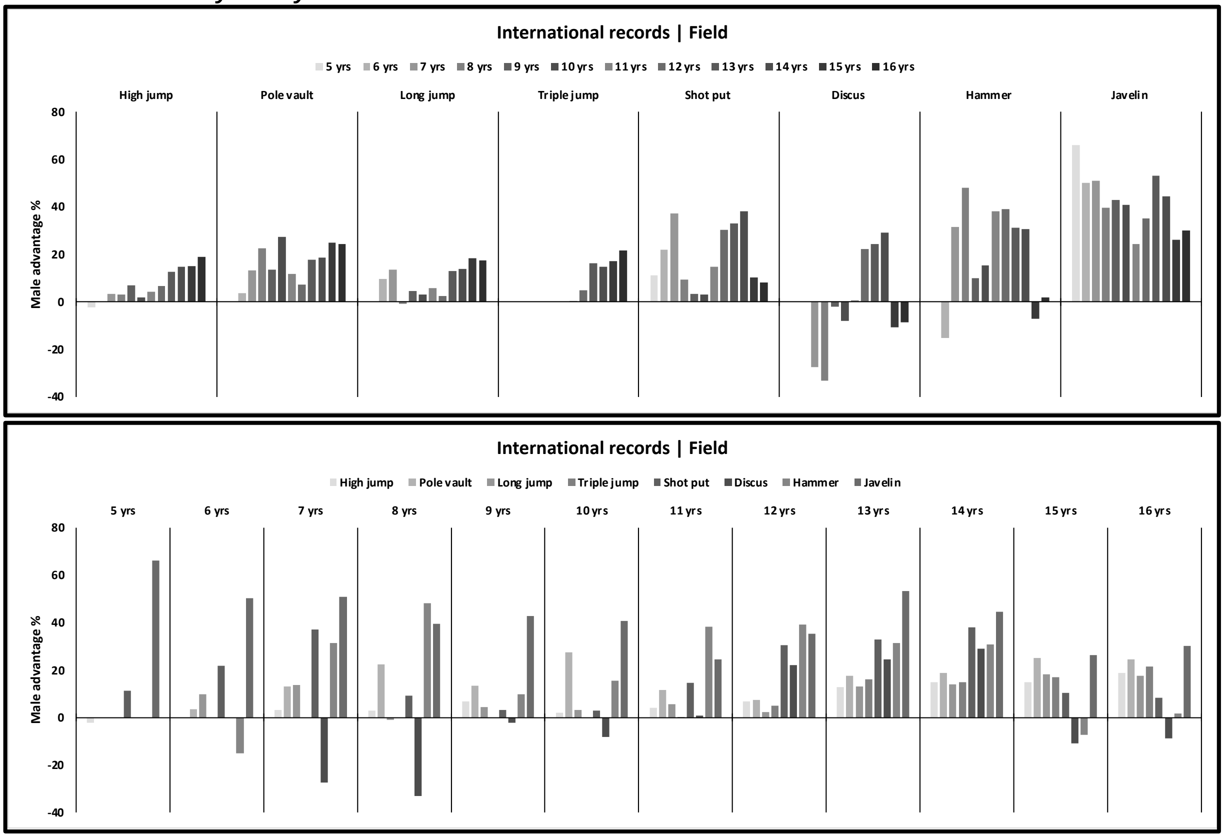
7.7 Also evident in this dataset is an unusually large male advantage for 3000 m at 7 years old. Analysis of the age progression for this event, shown in Figure 5, reveals this is underpinned by an unexpectedly poor female record for 3000 m at 7 years old. Thus, the extent of male advantage here is likely an overestimate of the true performance gap.

Figure 5. Age progression in the 3000 m in international schoolchildren records.
Abbreviations: yrs – years old, s – seconds



7.8 The male advantages (%) in field events, stratified by both event (upper panel) and age (lower panel), are shown in Figure 6. In field events, male advantage is again evident in all age groups and for all events, although this appears less systematic than in track events.

Figure 6. The male advantage over females in international schoolchildren records in field events, stratified by event (upper panel) and age group (lower panel). Abbreviations: yrs – years old

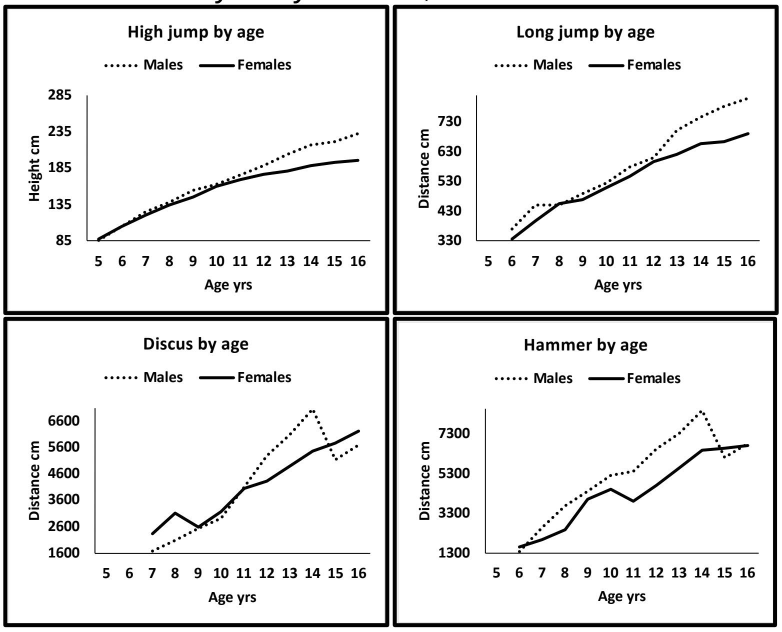


7.9 There are several field events where female schoolchildren appear to outperform their male peers, listed in Table 4. I examined the age progression of these events to seek to understand this apparent female advantage. These data are shown in Figure 7. For the high jump at 5 years old, in the absence of a preceding datapoint, it is impossible to evaluate the female advantage here. For the long jump at 8 years old, the female advantage appears to be explained by the convergence of an unusually poor male record and unusually good female record in this event.

Table 4. Female advantage in international schoolchildren field records. Abbreviations: yrs – years old, m – metres

Event	Age group	Female advantage %
High jump	5 yrs	2.3 %
Long jump	8 yrs	0.9 %
Discus	7 yrs	27.4 %
	8 yrs	33.1 %
	9 yrs	2.1 %
	10 yrs	8.1 %
	15 yrs	10.8 %
	16 yrs	8.7 %
Hammer	6 yrs	15.1 %
	15 yrs	7.2 %

Figure 7. Age progression in the high jump, long jump discus and hammer in international schoolchildren records.
Abbreviations: yrs – years old, cm – centimetres



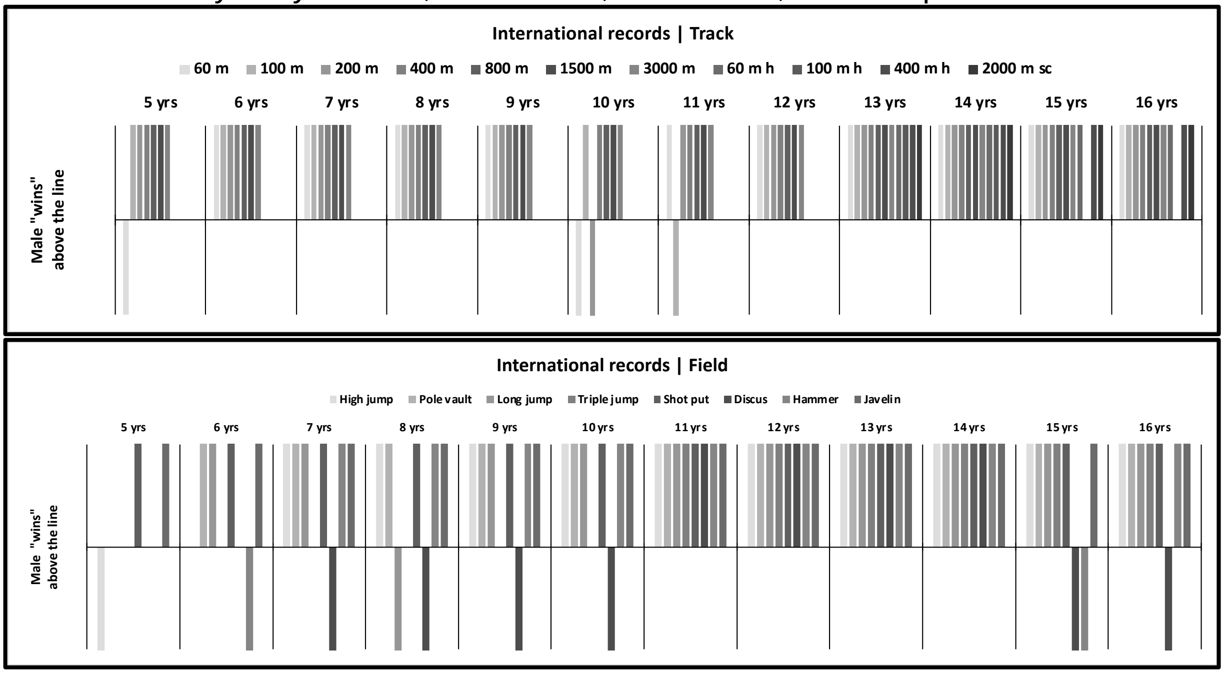
7.10 There are several throw events where female schoolchildren appear to outperform their male peers by a large distance. However, there are important confounding factors in throwing events, given that the weight of throwing implements can differ between male and female athletes at different ages. For the discus, girls at 7-8 years old throw a discus weighing 500 g, compared to boys of the same age using a 750 g discus. I hypothesise that a similar implement weight at 7-8 years old would mitigate or remove the apparent female advantage here. Between 9-14 years old, both sexes use a 1 kg discus. Performance between males and females seems broadly matched until 11 years old, which may be underpinned by earlier female puberty. Males open up the performance gap at 11 years old. At 15 years old, boys switch to a 2 kg discus. I believe it is reasonable, given the increasing male gap to 14 years old with the same implement weight of 1 kg, that a matched implement weight between males and females at 15-16 years old would reverse the apparent female advantage in favour of clear male advantage.

7.11 For the hammer, male and females use a 2 kg implement between the ages of 6-10 years old. At 6 years old, in the absence of a preceding datapoint, it is impossible to evaluate the female advantage here. Male advantage is evident from 7-10 years old; the ‘catch up’ with male peers at ages 9-10 years old may be explained by the physical changes of female puberty. Between the ages of 11-14 years old, both males and females use a 4 kg hammer, and male advantage is consistent through these ages. At 15 years old, males switch to a 7.26 kg hammer. I believe it is reasonable, given the male advantage evident throughout the time period where both sexes use a 4 kg hammer, that a matched implement weight between males and females at 15-16 years old would reverse the apparent female advantage in favour of clear male advantage.

7.12 Interestingly, male advantage is evident in all shot put and javelin events at all ages, despite increases in implement weight at 15-16 years old for males.

7.13 I formulated a null hypothesis: if there are no sex differences in athletic performances in schoolchildren, males and females are equally likely to hold the best record in any event. Therefore the frequency of males with the best record should be approximately equal to the frequency of females with the best record. To interrogate this statistically, I scored all track and field events at all ages as a binary variable of male “wins” versus female “wins” (whichever record was the fastest, longest, etc). I ignored potential confounding explanations in various events; that is, female advantage was scored as a “female win”, even if the female advantage is likely an artifact of, for example, earlier puberty or lighter implement weight. Thus, this scoring is deliberately generous to ensure the strength of any findings. Scoring data are visualised in Figure 8, with track events in the upper panel and field events in the lower panel. It is already clear from this analysis that the majority of “wins” go to male schoolchildren.

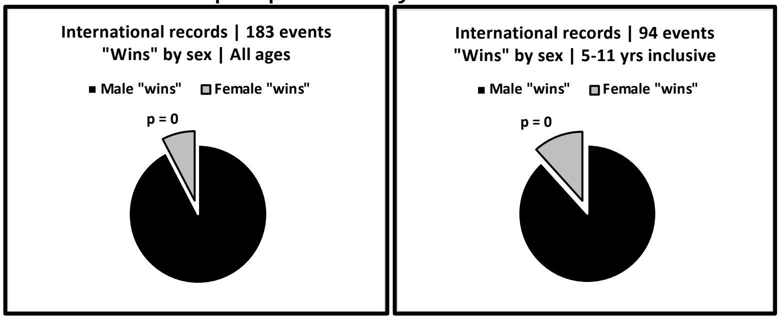
Figure 8. Male versus female “wins” in international schoolchildren records, scored in track events (upper panel) and field events (lower panel).
Abbreviations: yrs – years old, m – metres, h – hurdles, sc – steeplechase



7.14 I counted the frequency of male “wins” versus female “wins” at all ages and in a sub-analysis limited to events in pre-puberty (5-11 years old) age groups. I then calculated the probability that the frequency of male “wins” versus female “wins” would occur by chance.[88] These data are shown in Figure 9. The majority of “wins” go to male schoolchildren, whether across all age groups or limited to pre-puberty age groups. The chances of this frequency of male “wins” occurring by chance in either age grouping is calculated at a probability of effectively zero (p = 0).

[88] https://homepage.divms.uiowa.edu/~mbognar/applets/bin.html

Figure 9. The frequency of male versus female "wins" across pooled events in all age groups (left) and limited to pre-puberty age groups (right).
Abbreviations: p – probability



7.15 Following the same process for international records above, I analysed junior records from 8-16 years old from USA Track and Field (USATF)[89] and the US Amateur Athletics Union (AAU).[90] For brevity here, these datasets are compiled in **Appendix 3** (USATF) and **Appendix 4** (AAU). These national datasets confirm the results obtained from international records. **To summarise the data obtained from international and national schoolchildren records in track and field: 1. male advantage over female peers is evident across track and field events from 8 years old onwards; 2. males systematically outperform their female peers from 8 years old at a frequency that is vanishingly unlikely to result by chance.**

7.16 Again, following the same process for international records above, I analysed Arizona middle school records from 8-16 years old (available to 2014).[91] For brevity here, this dataset is compiled in **Appendix 5**. This dataset confirms that male advantage over female peers is predominant across track and field events from 8 years old. In these state level records, more female "wins" are scored in lower age groups than seen in international and national records. However, the frequency of male "wins" between 8-12 yrs old is still statistically unlikely to result from chance ($p = 0.043$, where $p = 0.05$ is the "significance" threshold).

7.17 I analysed the outcomes of two individual middle-school competitions. The first was the Kyrene District Track and Field Championship, held in April 2023.[92] Middle-schoolers participated in 13 events, and I calculated the male advantage for the winners of each matched event. These data are shown in Figure 10. In this school district championship, male advantage was evident in all events. I pooled all events then plotted the frequency of male versus female "wins" in this group of athletes. Again, I calculated the probability that the male "win" frequency would occur by chance. These data are shown in Figure 11. The probability that males would win all these events by chance is vanishingly low.

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[89] https://www.usatf.org/resources/statistics/records/championship-meet-records/usatf-national-junior-olympic-track-field-champion
[90] https://aautrackandfield.org/Results
[91] http://www.usatf.com/assoc/az/records.html
[92] https://www.athletic.net/TrackAndField/meet/486419/results/all

Figure 10. The male advantage over females at the Kyrene District Track and Field Championship, held in April 2023.
Abbreviations: m – metres, h – hurdles, SMR – sprint medley relay

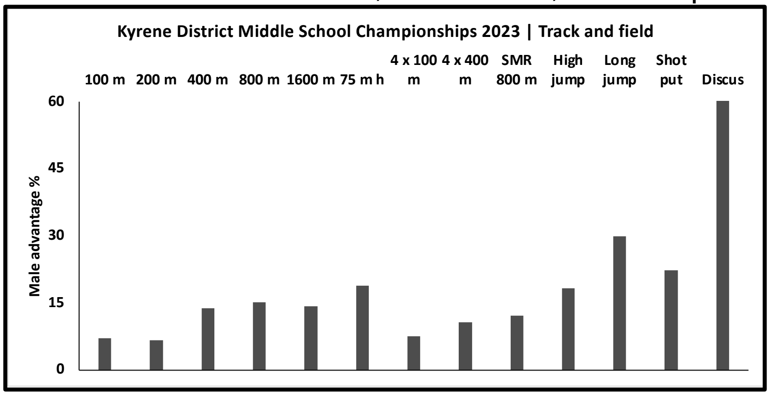
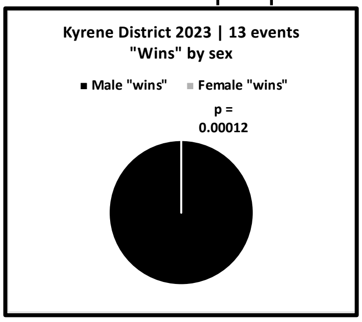
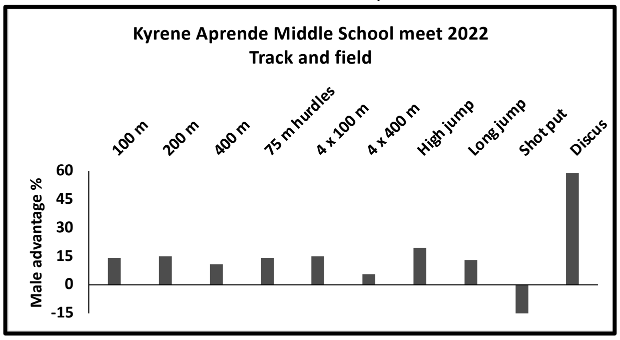


Figure 11. The frequency of male versus female "wins" across the pool of events at the Kyrene District Track and Field Championship, held in April 2023.
Abbreviations: p – probability



7.18 The second middle-school competition I analysed was the Kyrene Aprende Middle School Track and Field meet, held in July 2022.[93] Middle-schoolers participated in 12 events; however, the girls' times for the 800 m and 1600 m were not recorded on the scoresheets so I was unable to include these in my analysis. I calculated the male advantage for the matched winners in the remaining 10 events. These data are shown in Figure 12. In this single school athletics meet, male advantage was evident in all events except the shot put, where the apparent female advantage was an unexpectedly large 14.8 %.

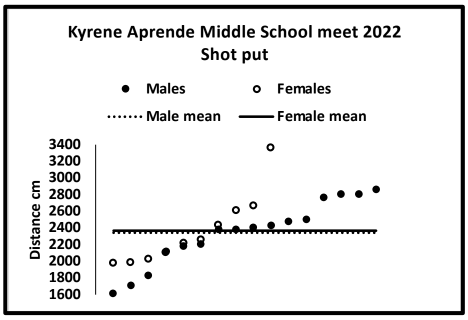
Figure 12. The male advantage over females at the Kyrene Aprende Middle School Track and Field meet, held in July 2022.
Abbreviations: m – metres, h – hurdles



[93] https://www.kyrene.org/Page/55102

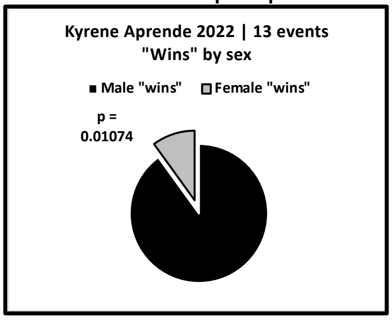
7.19 To understand the source of this female advantage in shot put, I analysed the puts of all the males and females at this middle school meet. These data are shown (with puts in increasing order of distance achieved) in Figure 13. The winner of the female competition putted 3360 cm, well beyond the second placed girl at 2670 cm. This winning female performance is 4.2 standard deviations from the female mean put distance, indicating an extraordinary performance with odds of occurrence of approximately 1 in 15000. A comparison of the mean distance putted by boys and girls shows them to be quite similar; however, the female winner is skewing this mean distance by 110 cm (the male winner only skews the male mean by 35 cm).

Figure 13. Analysis of puts at the Kyrene Aprende Middle School Track and Field meet, held in July 2022.
Abbreviations: cm - centimetres



7.20 I pooled all events then plotted the frequency of male versus female "wins" in this group of athletes. Again, I calculated the probability that the male "win" frequency would occur by chance. These data are shown in Figure 14. The probability that males would win almost all the events by chance is very low (p = 0.05 is the "significance" threshold).

Figure 14. The frequency of male versus female "wins" across the pool of events at the Kyrene Aprende Middle School Track and Field meet, held in July 2022.
Abbreviations: p – probability



7.21 Analyses of international, national and state track and field performances in male and female schoolchildren evidence sex differences in athletic performance, even before puberty. Sex differences in athletic performance are evident in middle school track and field meets. Collectively, these data demonstrate that female children require a female category of sport to win.

7.22 Childhood male athletic advantage over females has been proposed as social in origin. That is, higher engagement in sport and exposure to rougher play may represent 'training advantage' over females who are somewhat socialised to engage in less physical activity.[94] However, despite suggesting that childhood performance gaps are possibly social in origin, Thomas and French (1985) identify an extremely large gap in throwing differences, evident from age 3 years old, that are "unlikely to be completely environmentally caused" and are unlikely, based on biological factors, to be eliminated by training. The performance gap in international and national track and field records, evident even before puberty, somewhat controls for this socialisation effect, given that one might expect engaged, sporty girls to be as well-trained as their male peers.

[94] For example: Thomas and French, 1985. Gender differences across age in motor performance a meta-analysis. Psychol Bull 98(2):260-282.

8 Sports categories and concepts of advantage

8.1 Sports where performance or competitor safety is affected by sex routinely employ a protected female category that excludes males, to secure fairness for (and, discipline-dependent, safety of) female athletes. This separation on the basis of sex in pursuit of fair, safe sports and sporting opportunities for female athletes is permissible under much national equality legislation, including, for example, the UK Equality Act 2010.[95]

8.2 Misunderstandings regarding the nature of categories and advantage are common. Sports categories control for baseline physiological differences in sex, age, and impairment (and occasionally weight) that affect results or outcomes independently of the characteristics sporting competition seeks to reward: talent, strategy, training and dedication. Various initiatives like leagues, which operate alongside categories, exist to permit participation of those with different amounts of talent, strategy, training and dedication.

8.3 Categories are rationalised on biological principles, understanding what effect factors like sex and age have on the human body. They exist to ensure physiological "bonuses" (being male, being young) do not obscure outcomes that should depend on talent, strategy, training, and dedication. It is via categories that fairness is achieved, and we ensure that winning opportunities for the more talented athlete—a fundamental characteristic of sport—are preserved. Protected categories like the female category are a necessary inclusion measure to ensure females have an equal opportunity to compete in sports.

8.4 Advantage exists regardless of magnitude. Indeed, sports bodies have a history of regulating for even very small advantages. For example, inside lane track runners closer to the traditional start gun hear the gun more quickly and more loudly than those in outside lanes, offering them a small kind of advantage unavailable to the whole field. To combat this advantage, worth around 150 milliseconds in a staggered start of a 400m track, runners typically now start races via a loudspeaker at each block.[96] Even if an apparent advantage is small, a category or rule operates to exclude any quantity of it.

8.5 A common argument is to frame 'advantage' as simply a property of results (for example, any person who is faster than any other has 'advantage', while people who are equally fast are said to be fairly-matched), one undermines the very existence of categories. The logical outcome is sports organised not to reward talent but to reward a combination of talent and talent-independent physical properties that together deliver a winning outcome. In such a framework, almost all sports at every competitive level will be dominated by able-bodied males aged around 20-35 years old.

8.6 What has traditionally been described as a "girl's/women's category" is more precisely understood as a category for females that excludes males who have acquired any magnitude of male athletic advantage by virtue of biology, regardless of performance relative to the female field. The ineligibility of those with any male advantage is necessary to maintain the integrity of the female sports category.

8.7 Puberty, where we see a sharp divergence of male and female athletic performance, is typically regarded as the age at which a protected female category becomes necessary. I believe, given the evidence I have presented in **Section 7** that demonstrates male advantage in childhood, that is justified from pre-puberty ages to institute a protected female category that excludes any male advantage, should fairness for young female athletes be a priority for regulators.

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[95] UK Equality Act 2010, Part 14, Section 195.

[96] Holmes, 2008. Olympic start gun gives inside runners an edge. New Scientist, 23rd June 2008.

9 Treatment of transgender girls and transgender women

9.1 Transgender girls and transgender women may take social, pharmaceutical and/or surgical steps to be perceived and treated as if they were female. In adulthood, transgender women may opt for testosterone suppression (for example, via gonadotropin-releasing hormone [GnRH] agonists, spironolactone or cyproterone acetate) then/or surgical removal of the testes; both of these interventions have the effect of lowering testosterone levels to those of females[97] and reducing the functional or visual impact of male physical characteristics. Estrogen supplementation typically promotes feminisation of, for example, breast tissue.[98]

9.2 Early pharmaceutical interventions in transgender girls may involve blocking male puberty via GnRH agonists ("puberty blockers"), administered after the onset of puberty (at least Tanner stage 2; in male children, the appearance of pubic hair, increase in testicular volume and reddening of scrotum skin).[99] This is typically followed by a regime of cross-sex hormones from 16 years old.

9.3 Many children reporting gender dysphoria or incongruent gender identity desist; that is, gender identity issues resolve with puberty.[100] For this reason, puberty blockers are not administered until after the onset of puberty and there is observed demonstrable persistence of gender identity issues. Furthermore, the reported effects and side-effects of puberty blockers are serious, including long-term effects on bone growth, brain development, fertility and sexual function, and short-term effects like headaches, hot flashes, mood swings, and depression and anxiety,[101] necessitating caution with their prescription.

9.4 Considering the potential for medical harm while outcomes remain uncertain, many jurisdictions have cautioned against or restricted the use of puberty blockers in children, including the Swedish National Board of Health and Welfare,[102] the Finnish Health Authority,[103] the French National Academy of Medicine[104] and the Norwegian Healthcare Investigation Board.[105] The UK NHS has recently restricted puberty blockers within clnical research.[106] Pioneers of the original protocol for treatment of childhood dysphoria have advocated re-evaluation considering the rapidly-changing cohort demographics.[107]

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97 Nishiyama, 2014. Serum testosterone levels after medical or surgical androgen deprivation: a comprehensive review of the literature. Urologic Oncology 32(1): 38.e17-28.

98 Unger, 2016. Hormone therapy for transgender patients. Translational Andrology and Urology. 5(6): 877-884.

99 Puberty progression is assessed using "Tanner staging", which describes the typical physical changes in boys and girls using landmarks of external genitalia in males (testicular volume, penis length and skin appearance), quantity and coarseness of pubic hair in both sexes, and breast development in girls. In males, Tanner stage 2 indicates the first signs of puberty, around the age of 11 years old, comprising the appearance of downy pubic hair, an increase in testicular volume and reddening of the scrotum skin. At Tanner stage 3, around the age of 13 years old, the penis begins to grow in length. Testicular volume increase and penis growth continues during later stages, and pubic hair becomes course and curly. For more information, see: https://childgrowthfoundation.org/wp-content/uploads/2020/03/Puberty-and-Tanner-Stages_v2.0.pdf

100 Wallien and Cohen-Kettanis, 2008. Psychosexual outcome of gender-dysphoric children. Journal of the American Academy of Child and Adolescent Psychiatry 47(12): 1413-1423.

101 Reported by various healthcare providers, for example: Mayo Clinic, NHS, St. Louis Children's Hospital.

102 https://www.socialstyrelsen.se/globalassets/sharepoint-dokument/artikelkatalog/kunskapsstod/2022-3-7799.pdf

103 https://palveluvalikoima.fi/documents/1237350/22895838/Summary+transgender.pdf/2cc3f053-2e34-39ce-4e21-becd685b3044/Summary+transgender.pdf?t=1592318543000

104 https://segm.org/sites/default/files/22.2.25-Communique-PCRA-19-Medecine-et-transidentite-genre.pdf

105 https://www.bmj.com/content/bmj/380/bmj.p697.full.pdf

106 https://www.england.nhs.uk/wp-content/uploads/2023/06/Interim-service-specification-for-Specialist-Gender-Incongruence-Services-for-Children-and-Young-People.pdf

107 de Vries, 2020. Challenges in Timing Puberty Suppression for Gender-Nonconforming Adolescents. Pediatrics 146(4): e2020010611.

9.5 When prescribed as above, puberty blockers do not, by definition, block the entirety of male puberty. They do not block any hormone-derived pre-puberty effects on male development. They are unlikely to interfere with genetic effects on male development.

10 Transgender women in sport

10.1 Given the role of testosterone in the development of the male characteristics that matter for sporting performance, and bearing in mind the typical pharmaceutical and medical treatment sought by transgender girls and transgender women, the International Olympic Committee (IOC) and other sporting federations have historically sought to include transgender women in female sports by regulating levels of testosterone prior to inclusion in female competition.[108] More recently, the IOC have suggested that "*testosterone levels could be investigated as a means to mitigate performance*" in transgender women.[109] It is inferred that the IOC believe testosterone suppression may be sufficient to remove the male performance advantage provided by male-typical secondary sex characteristics.

10.2 In 2020, with the IOC equivocating over a review of their testosterone guidelines, Dr Tommy Lundberg and I tested the existing guidelines' promise to protect fair competition, by reviewing peer-reviewed published longitudinal changes in muscular and skeletal metrics in transgender women suppressing testosterone in adulthood for a minimum of 12 months.[110] Having reviewed measures of bone density, lean body mass, muscle mass and strength tests, we identified a unified consensus in original studies covering approximately 800 transgender women that skeletal metrics like height and bone length were unaffected, bone mass was preserved, and muscle mass and strength was decreased by 4% over 12 months of testosterone suppression. Within this dataset, compared with female control cohorts, higher muscle mass/strength values—between +13-41 %—were maintained for at least three years after testosterone suppression (the limit of current longitudinal studies).

10.3 These observations were subsequently reinforced by a systematic review of the same dataset published by another group later in 2021, which concluded that, in transgender women, "*hormone therapy decreases strength, [lean body mass] and muscle area, yet values remain above that observed in cisgender women, even after 36 months. These findings suggest that strength may be well preserved in transwomen during the first 3 years of hormone therapy.*"[111]

10.4 To gain an overall picture of the baseline metrics and effects on muscle mass and strength in transgender women pre- and post- at least 12 months of testosterone suppression, I compared pre- and post- metrics for transgender women across the Hilton and Lundberg dataset with data from control males and females, shown in Figure 15. Original study metrics were converted to relative percentages, with pre-suppression metrics in transgender women set at 100%. The 4% reduction in muscle mass and strength in transgender women pre- and post- at least 12 months of testosterone suppression was not statistically significant. The difference between transgender women and control males was statistically significant, with transgender women pre- and post- at least 12 months of testosterone suppression deviating from control males by -7% and -11%, respectively. The difference between transgender women and females is also statistically significant; transgender women pre- and post- at least 12 months of

[108] https://stillmed.olympic.org/Documents/Commissions_PDFfiles/Medical_commission/2015-11_ioc_consensus_meeting_on_sex_reassignment_and_hyperandrogenism-en.pdf

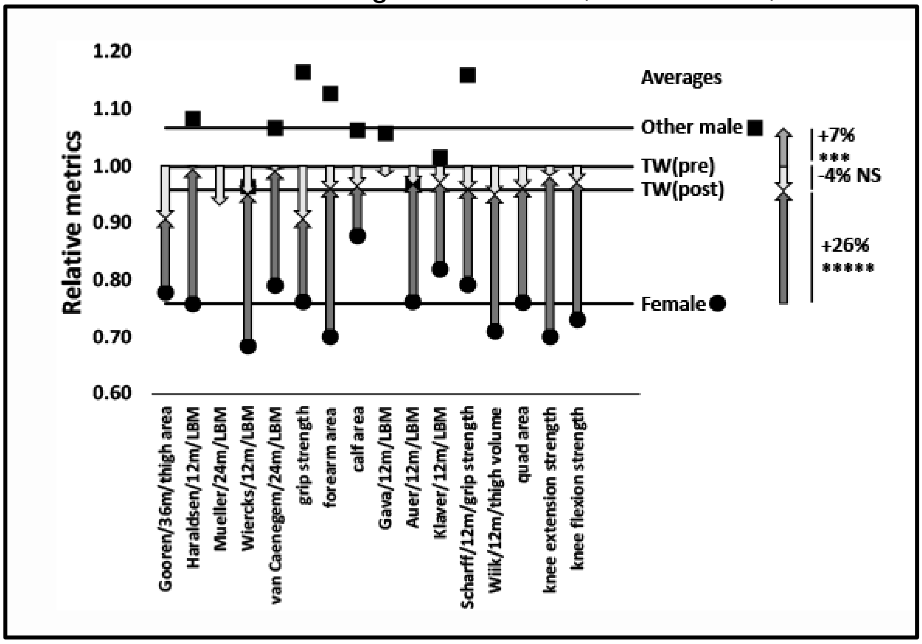
[109] Martowicz et al., 2023. Position statement: IOC framework on fairness, inclusion and non-discrimination on the basis of gender identity and sex variations. Br J Sports Med 57:26–32.

[110] Hilton and Lundberg, 2021. Transgender Women in the Female Category of Sport: Perspectives on Testosterone Suppression and Performance Advantage. Sports Medicine 51, 199–214. Note: the date disparity of the published paper represents the gap between article submission and publication.

[111] Harper et al., 2021. 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. Br J Sports Med 55: 865-872.

testosterone suppression deviate from control females by +35% and +30%, respectively. It appears that for metrics of muscle mass and strength, transgender women remain within ‘male range’.

Figure 15. Relative metrics in transgender women pre- and post- testosterone suppression, compared with control males and females.
Abbreviations: TW – transgender women, m – months, NS – not significant



10.5 In addition to the longitudinal data captured by the above reviews, there are three significant cross-sectional studies of physical metrics in transgender women suppressing testosterone. The first found that transgender women, after an average of 8 years of suppressed testosterone, had a lean body mass in the 90th percentile for females, and grip strength that remained 25 % higher than the female reference value.[112] The second, in transgender women suppressing testosterone for just over 3 years, showed that those transgender women had a mean lean body mass 18 % higher than the mean in control females.[113] The third found that transgender women suppressing testosterone for over 14 years retained higher cardiopulmonary capacity metrics and higher hand grip strength than female controls.[114]

10.6 In 2015, to assess sports performance in transgender women, an observational cohort study of transgender women runners was performed, studying race times before and after testosterone suppression.[115] Participants were club-level middle-distance runners. After applying an age-grading formula typically reserved for Masters athletes, performance in the female category was judged to be maintained at a level equivalent to pre-suppression performance in the male category. This study had a sample size of eight runners self-reporting times that were unverifiable in 50% of cases and spanning a period of decades. The study could not make any controls for ageing, training, diet,

[112] Lapauw et al., 2008. Body composition, volumetric and areal bone parameters in male-to-female transsexual persons. Bone. 43(6):1016–1021.
[113] Bretherton et al., 2021. Insulin resistance in transgender individuals correlates with android fat mass. *Ther Adv* Endocrinol Metab 12:2042018820985681.
[114] Alvares et al., 2022. Cardiopulmonary capacity and muscle strength in transgender women on long-term gender-affirming hormone therapy: A cross-sectional study. Br J Sports Med 56: 1292-1298.
[115] Harper, 2015. Race times for transgender athletes. Journal of Sporting Cultures and Identities 6:1-9.

injury, running course, or course weather conditions. The overall cohort analysis included times from runners who had experienced chronic injury and loss of fitness, resulting in poorer-than-expected performance within the female field. However, excluded from the overall analysis was a runner who had achieved a far higher ranking competing in female running than in male running. This individual improved ranking significantly, and even recorded a marathon that was faster than previous marathon performance in the male category, but was considered an outlier who had seriously intensified her training after transition into female sport. This individual demonstrates, as argued in Hilton and Lundberg, that training during testosterone suppression can mitigate negative performance effects.

10.7 There have been two studies of athletic performance in military personnel using basic fitness testing data.[116] While not athletes, these individuals do represent a trained population of transgender people. Both studies tracked changes in push-up, sit-up and 1.5 mile run performance during annual fitness testing over 3 or 4 years of testosterone suppression. Such tests are 'work to target': recruits are aware of targets that must be achieved to pass the fitness testing process, minimum performances must be achieved for each test, and a cumulative score threshold must be reached to pass the fitness test. Individual officers have the latitude to "choose" how their scores are allocated, such that a particularly strong runner has a lower need to gain points during the push-up test (for example). The performances cannot thus be assessed as maximal performances, but instead may be considered as paced performances with conscious knowledge of a required standard. The authors of the first study acknowledge that, despite being in a controlled environment of the Air Force, the exercise intentions and training habits of the recruits was unknown, and over a period of three years, changes in training with material implications for muscle and cardiovascular performance cannot be known.

10.8 Significantly, the data from the two studies of athletic performance in military personnel make contradictory findings, presented in Table 5. Roberts et al. (2021) finds that both push-up and sit-up performance are statistically equivalent to female performance after 2 years while advantage in running performance is retained to 2 years. However, Chiccarelli et al. (2022) finds that push-up advantage is retained beyond 4 years, sit-up performance is statistically equivalent to female performance at 4 years and running performance is statistically equivalent to female performance at 2 years.

10.9 This set of performance studies suffer from small numbers of participants, lack of controls for performance times, and issues regarding the validity of performance tests. They cannot be used in isolation to inform sports policy, particularly when the overwhelming body of evidence suggests that the effects of testosterone suppression on important metrics like muscle mass and strength are marginal and that male development, and thus male advantage, cannot be reversed.

[116] Roberts et al., 2021. Effect of gender affirming hormones on athletic performance in transwomen and transmen: Implications for sporting organisations and legislators. Br J Sports Med 55:577-583; Chiccarelli et al., 2022 Fit transitioning: When can transgender airmen fitness test in their affirmed gender? Mil Med 2022;usac320.

Table 5. A comparison of the findings of two studies of athletic performance in military personnel.
Abbreviations: NA – not applicable, * – year at which statistical parity with females is reached

	Roberts et al., 2021 Year group % change (% advantage over female controls)			**Chiccarelli et al., 2022** Year group % change (% advantage over female controls)		
	Push-ups	**Sit-ups**	**Running**	**Push-ups**	**Sit-ups**	**Running**
Pre-transition	NA (+45.5 %)	NA (+17.3 %)	NA (+17.2 %)	NA (66.3 %)	NA (+28.3 %)	NA (+17.8 %)
Year 0-1	-5.7 % (+37.2 %)	+1.1 % (+18.6 %)	-7.1 % (+11.3 %)	-13.0 % (+44.7 %)	-6.1 % (+20.5 %)	-10.4 % (+9.2 %)
Year 1-2	-3.1 % (+32.9 %)	-4.3 % (+13.6 %)	-4.4 % (+7.5 %)	-9.4 % (+31.0 %)	-2.6 % (+17.3 %)	-4.5 % (+5.1 %)*
Year 2-3	-19.9 % (+6.5 %)*	-13.5 % (-1.8 %)*	+3.3 % (+10.5 %)	-2.0 % (+28.3 %)	-5.2 % (+11.2 %)	-0.0 % (+5.1 %)*
Year 3-4				-8.3 % (+17.7 %)	-2.6 % (+8.3 %)*	-5.2 % (+0.2 %)*

11 Transgender girls in sport

11.1 Most sporting federations exempt from testosterone regulations those who have blocked puberty before cross-sex hormone treatment. To my knowledge, there is no published data on muscle mass and strength metrics in a cohort of transgender girls who have blocked puberty from Tanner stage 2.

11.2 Recently available is a study by Boogers et al. (2022) called, "Trans girls grow tall: adult height is unaffected by GnRH analogue and estradiol treatment."[117] In this study, transgender girls who had received puberty blockers from around 13 years of age, then cross-sex hormones at 16 years of age, acquired an average adult height of 180.1-185.3 cm, far larger than the population female average (170.7cm) and around the population male average (183.8cm). The authors conclude that the driver of height acquisition is genetic in origin, and not a result of testosterone during puberty.

11.3 In two studies where male puberty was partially-blocked, lean body mass in young adulthood remains higher than in reference females[118] and grip strength remains higher than in a matched cohort of transgender boys.[119]

11.4 Claims that transgender girls who block puberty do not acquire any male athletic advantage in terms of skeletal structure and/or muscle mass are speculative.

[117] Boogers et al., 2022. Trans girls grow tall: adult height is unaffected by GnRH analogue and estradiol treatment. Journal of Clinical Endocrinology and Metabolism. Epub ahead of print, PMID: 35666195.
[118] Klaver et al., 2018. Early Hormonal Treatment Affects Body Composition and Body Shape in Young Transgender Adolescents. Journal of Sexual Medicine 15(2): 251-260.
[119] Tack et al., 2018. Proandrogenic and Antiandrogenic Progestins in Transgender Youth: Differential Effects on Body Composition and Bone Metabolism. Journal of Clinical Endocrinology and Metabolism 103(6): 2147-2156.

I verify under the penalties for perjury that the foregoing representations are true.

Emma Hilton, PhD
27th June 2023

Appendix 1.
Emma Hilton Short-form academic CV

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ROLES

04/2019 - present	Postdoctoral research associate, Division of Infection, Immunity & Respiratory Medicine, University of Manchester (funding from BBSRC; NC3Rs; Cystic Fibrosis Foundation).
01/2014 - 04/2019	Research Fellow, University of Manchester (funding from MRC, Newlife).
01/2010 - 01/2014	Stepping Stone Research Fellow, Genetic Medicine, University of Manchester (funded internally).
06/2003 - 12/2009	Postdoctoral research associate, Genetic Medicine, University of Manchester (MRC).

ACADEMIC QUALIFICATIONS

2004	Ph.D. Developmental Biology, University of Warwick, UK.
1999	B.Sc. (Honours) Biochemistry, University of Warwick, UK.

PUBLICATIONS (Google Scholar: Citations 1181, h-index 16)

Randles, M., Hamidi, H., Lausecker, F., Humphries, J.D., Byron, A., **Hilton, E.N.**, Clark, S.J., Miner, J.H., Zent, R., Humphries, M.J. and Lennon, R. Integrin-specific signalling pathways determine podocyte morphologies on basement membrane ligands. Submitted, Nat. Commun.

Hilton, E., Thompson, P., Wright, C. and Curtis, D. (2021). The Reality of Sex. Ir J Med Sci 190(4): 1647-1647.

Hilton, E. and Lundberg, T. (2021). Transgender women in the female category of sport: perspectives on testosterone suppression and performance advantage. Sports Med. 51 (2), 199-214.

Hindi, E., Williams, C., Zeef., L., Lopes, F., Newman, K., Davey, M., Hodson, N., **Hilton, E.**, Huang, J., Price, K., Roberts, N., Long, D., Woolf, A. and Gardiner, N. (2021). Experimental long-term diabetes mellitus alters the transcriptome and biomechanical properties of the rat urinary bladder. Sci Rep. 11(1):1-16.

Roberts, N.A., **Hilton, E.N.**, Lopes, F., Randles, M., Singh, S., Chopra, K., Coletta, R., Bajwa, Z., Hall, R., Yue, W. et al. (2019). Lrig2 and Hpse2, mutated in urofacial syndrome, pattern nerves in the urinary bladder. Kidney Int. 95(5):1138-1152.

Roberts, N.A., **Hilton, E.N.**, and Woolf, A.S. (2016). From gene discovery to new biological mechanisms: heparanases and congenital urinary bladder disease. Nephrol Dial Transplant. 31(4):534-540.

Stuart, H.M,, Roberts, N.A., **Hilton, E.N.**, McKenzie, E.A., Daly, S.B., Hadfield, K.D., Rahal, J.S., Gardiner, N.J., Tanley, S.W., Lewis, M.A. et al. (2015). Urinary tract effects of HPSE2 mutations. J Am Soc Nephrol. 26(4):797-804.

Roberts, N., Woolf, A. S., Stuart, H., Thuret, R., McKenzie, E., Newman, W. G., and **Hilton, E. N.** (2014). Heparanase 2, mutated in urofacial syndrome, mediates peripheral neural development in Xenopus. Hum Mol Genet 23:4302-4314.

Woolf, A.S., Stuart, H.M., Roberts, N.A., McKenzie, E.A., **Hilton, E.N.**, and Newman, W.G. (2013). Urofacial syndrome: a genetic and congenital disease of aberrant urinary bladder innervation. Pediatr Nephrol. 29(4):513-518.

Stuart H.M., Roberts, N.A., Burgu, B., Daly, S.B., Urquhart, J.E., Bhaskar, S., Dickerson, J.E., Mermerkaya, M., Silay, M.S., Lewis, M.A. et al. (2013). LRIG2 Mutations Cause Urofacial Syndrome. Am J Hum Genet. 92(2):259-264.

Maher, G.J., **Hilton, E.N.**, Urquhart, J.E., Davidson, A.E., Spencer, H.L., Black, G.C., Manson, F.D. (2011). The cataract-associated protein TMEM114, and TMEM235, are glycosylated transmembrane proteins that are distinct from claudin family members. FEBS Lett. 585(14):2187-2192.

Banka, S., Walter, J., Aziz, M., Urquhart, J. Vassallo, G., Clouthier, C.M., Rice, G., **Hilton, E.**, Will, A., Wevers, R.A. et al. (2011). Identification and characterisation of a novel inborn error of metabolism caused by dihydrofolate reductase deficiency. Am J Hum Genet. 88(2):216-225.

Briggs, T.A., Rice, G.I., Daly, S., Urquhart, J., Gornall, H., Bader-Meunier, B., Baskar, K., Baskar, S., Baudouin, V., Beresford, M.W. et al. (2011). Tartrate-resistant acid phosphatase deficiency causes a bone dysplasia with autoimmunity and a type I interferon expression signature. Nat Genet. 43(2):127-131.

Daly, S.B., Urquhart, J.E., **Hilton, E.**, McKenzie, E.A., Kammerer, R.A., Lewis, M., Kerr, B., Stuart, H., Donnai, D., Long, D.A. et al. (2010). Mutations in HPSE2 cause urofacial syndrome. Am J Hum Genet. 86(6):963-969.

Hilton, E.N., Johnston, J., Whalen, S., Okamoto, N., Hatsukawa, Y., Nishio, J., Kohara, H., Hirano, Y., Mizuno, S., Torii, C. et al. (2009). BCOR analysis in patients with OFCD and Lenz microphthalmia syndromes, mental retardation with ocular anomalies, and cardiac laterality defects. Eur J Hum Genet. 17(10):1325-1335.

Hanson, D., Murray, P.G., Sud, A., Temtamy, S.A., Aglan, M., Superti-Furga, A., Holder, S.E., Urquhart, J., **Hilton, E.**, Manson, F.D.C. et al. (2009). The primordial growth disorder 3-M syndrome connects ubiquitination to the cytoskeletal adaptor OBSL1. Am J Hum Genet. 84(6):801-806.

Tassabehji, M., Fang, Z., **Hilton, E.N.**, McGaughran, J., Zhao, Z., de Bock, C.E., Howard, E., Malass, M., Donnai, D., Diwan, A. et al. (2008). Mutations in GDF6/BMP13 are associated with vertebral segmentation defects in Klippel-Feil syndrome. Hum Mutat. 29(8):1017-1027.

Hilton E.N., Black, G.C., Manson, F.D., Schorderet, D.F., Munier, F.L. (2007). De novo mutation in the BIGH3/TGFB1 gene causing granular corneal dystrophy. Br J Ophthalmol. 91(8):1083-1084.

Hilton, E.N., Manson, F.D., Urquhart, J.E., Johnston, J.J., Slavotinek, A.M., Hedera, P., Stattin, E.L., Nordgren, A., Biesecker, L.G., Black, G.C. (2007). Left-sided embryonic expression of the BCL-6 corepressor, BCOR, is required for vertebrate laterality determination. Hum Mol Genet. 16(14):1773-1782.

Hilton, E.N., Rex, M., Old, R. (2003). VegT activation of the early zygotic gene Xnr5 requires lifting of Tcf-mediated repression in the Xenopus blastula. Mech Dev. 120(10):1127-1138.

Rex, M., **Hilton, E.N.**, Old, R. (2002). Multiple interactions between maternally-activated signalling pathways control Xenopus nodal-related genes. Int J Dev Biol. 46(2):217-226.

AUTHORED BOOK CHAPTERS

Hilton, E., Black, G.C.M., Bardwell, V. BCOR and oculofaciocardiodental syndrome. (2008/2013). Epstein's Inborn Errors of Development: The Molecular Basis of Clinical Disorders of Morphogenesis, 2nd/3rd edition, Oxford University Press, Oxford, UK.

GRANT INCOME

2016-2018	Newlife (£115,735). Towards novel therapies for an inherited congenital neuropathy affecting the urinary bladder. Woolf, Newman, Kimber, **Hilton** (Co-app).
2014-2016	MRC (£507,695). Molecular bases of congenital bladder diseases. Woolf, Newman, Gardiner, **Hilton** (Research Co-I).
2010-2013	KRUK (£180,000). Urofacial syndrome (UFS): a novel genetic model to understand human renal tract function and malformation. Newman, Woolf, McKenzie, **Hilton** (Co-app).
2010-2014	University of Manchester (£salary + £40,000 project costs). Xenopus as a model organism for human development and disease. **Hilton** (Stepping Stone Fellowship Award).
2008-2010	Newlife (£100,000). The role of BCL-6 corepressor-modulated TGFβ signalling in MCOPS2 and other microphthalmia syndromes. Black, Manson, **Hilton** (Co-applicant).

Appendix 2.
Hilton and Wright, 2023. “Two sexes”. Sex and Gender: A Contemporary Reader. Routledge, Oxford, UK.

TWO SEXES
Emma Hilton and Colin Wright

‘Why the sexes are, in fact, always two.’
Sir Ronald Fisher, 1930

Sex is an evolved system function common to almost all complex life on earth, a fact that is often forgotten by postmodernist commentators intent on framing sex as a human-centred, human-invented—and thus malleable—construction of scientific understanding. The aim of this essay is to review the biological understandings of the phenomenon that is sex.

In the first section, we will answer the question: why does sex exist? We will explain its evolutionary origins, and the binary gamete system on which ‘female’ and ‘male’ are founded. To finish this section, we explore some of the diversity of sex—female and male—in the natural world, to understand how reproductive bodies in almost all complex life are organised around these functional roles. In the second section, we will focus on developmental biology and how sex manifests in humans: how we make babies and how female and male humans develop. In the final section of this chapter, we will critique emerging ideological misinformation about sex, particularly in humans, addressing arguments that, for example, assert sex as a social construct or seek to deconstruct standard understandings of sex as a binary phenomenon. We will highlight fundamental misinterpretations of sex and its associated characteristics, the unscientific focus on those people with atypical sex development and the dangers of viewing sex as a statistical outcome.

The incursion of ideological misinformation about sex into the academic fields of medicine and biology generates confusion in research and presents potential for harm. ‘Sex matters’ in basic and applied health research (Wizemann and Pardue, 2001) and the US National Institutes of Health, the EU Commission, research funding bodies and academic journals increasingly demand that researchers account for ‘sex as a biological variable’ in their research design, analyses and reporting, whether they include studies of whole organisms or cell lines. However, progress is slow. The UK NHS maintains a confusing system where biological sex cannot be disaggregated (Forstater, 2021), and the World Health Organisation promises to, ‘achieve greater impact on health [using] sex disaggregated data’ (WHO/Health topics/Gender) while simultaneously updating guidance to assert that, ‘sex is not limited to male or female.’ (WHO, 2022). We have publicly argued that, from the wider scientific perspective, ideologically-driven scientists are in danger of sacrificing, ‘empirical fact in the name of social accommodation’ and this is both, ‘an egregious betrayal to the scientific community they represent’ and, ‘undermines public trust in science.’ (Hilton and Wright, 2020). By re-asserting biological knowledge established over the preceding centuries and countering deconstructive discourse, this essay may be considered a reconstruction of sex.

A note on language. Physiologist Ernst Wilhelm von Brucke noted that, ‘Teleology is a lady without whom no biologist can live. Yet he is ashamed to show himself with her in public.’ (Davis and Uhrin, 1991). It is possible in discussions of evolutionary biology to avoid teleological language, but sentence constructions are often overly verbose and clunky. For ease of readability, we sometimes use language that is teleological in tone, but, in the words of zoologist

Simon Maddrell (1998), ‘This should not be taken to imply that evolution proceeds by anything other than from mutations arising by chance, with those that impart an advantage being retained by natural selection.’

WHAT IS SEX?
And why does sex exist? Remarkably, it is not uncommon to find purportedly-scientific articles about sex that neglect to mention its evolved function of reproduction (for example, Ainsworth, 2015; Sun, 2019). Indeed, that science communicators writing about sex often focus only on lists of physical characteristics associated with sex means that, despite the author claims, such articles are not actually addressing the biological phenomenon of sex—what is it? why does it exist? why do humans have sexed bodies? Rather, they are addressing how the sex of a given individual may be identified via some checklist of physical features that—ironically—could only have been created by understanding how those physical features are associated with reproductive function. We return to this conflation of sex (what it is) with the physical characteristics associated with sex (how we recognise the sex of a given individual) in the final section of this essay.

Reproduction The phenomenon of sex is rooted in reproduction, the process by which new individuals are produced from a parent or parents. There are two types of reproduction in the natural world: asexual and sexual. In asexual reproduction, a parent replicates all of its genetic information and generates new individuals by processes such as binary fission—the division of a parent cell into two identical (or, at least, very similar) cells, observed in bacteria—and budding—which produces a new individual from a parental outgrowth, observed in yeast.

In asexual reproduction, offspring receive a full set of genetic information from a single parent; it follows that offspring are genetically-identical clones of that parent. Individual expansion, via asexual reproduction, of a genetically-identical (or genetically-similar) population is a relatively low-cost biological burden, and rapid to enact; consider how quickly mould, which can reproduce asexually via the production of independent spores that populate the local environment, can colonise a loaf of bread, or how quickly bindweed can aggressively invade a garden by sending out roots from which new individuals grow. There are also parental benefits, as each parent passes on all of its genetic information to the next generation.

Yet despite the existence of a low-cost and rather straightforward method of reproduction, the natural world is dominated by species that employ a different reproductive strategy: sexual reproduction.

Unlike asexual reproduction, sexual reproduction involves two parents, almost always from two different classes of individuals called ‘females’ and ‘males’; each contributes half of their genetic material—carried on chromosomes—resulting in the generation of a new and genetically-unique individual. The mixing of genetic material from each parent (and thus, the beginning of a new individual) is achieved, in a process called ‘fertilisation’, by the fusion of two specialised cells called ‘gametes’. Gametes are a unique cell type within sexually-reproducing species and the function of the gamete within any individual is singular—to effect sexual reproduction.

Sexual reproduction is biologically-costly to individuals, not least because mating requires resources (for example, energy expended on locating a mate) and carries health risks (for example, disease transmission and exposure to predators). In most sexually-reproducing populations, half of the offspring will be males who cannot themselves bear offspring; thus, these populations experience lower growth rates than found in asexual populations, where all offspring can themselves bear offspring ('the cost of males'; Maynard Smith, 1978). Furthermore, genetic relatedness between parent and offspring is much lower than in asexually-generated clones, and each individual must therefore invest biological resources in producing at least two offspring to have any chance of passing all genetic material to the next generation. Explaining these costs—the 'queen of problems in evolutionary biology' (Bell, 1982)—has challenged evolutionary biologists; given the disadvantages, why did sexual reproduction evolve from asexual reproduction to become, by far, the most common method of reproduction in complex species?

The fusion of two gametes means that the new individual possesses a chromosomal makeup different to either parent and, given recombination between the chromosomes in each parent, chromosomes that carry different combinations of genetic material to either parent. The prevalence of sexual reproduction indicates a strong evolutionary advantage for this mechanism of reproduction that mixes genetic material. Such advantage is typically conceptualised as novel combinations of genes and changes in them (mutations) upon which evolutionary selection can act, the foundation of Darwin's theory of evolution by natural selection (Darwin, 1859), and divided into two broad hypothesis domains: the accumulation of beneficial genetic changes and the removal of detrimental genetic mutations. Accumulation of beneficial genetic traits are advantageous in adaptation to changing environments (the 'Fisher-Muller model'; Fisher, 1930; Muller, 1932) or co-adaptation, in an arms race, alongside interacting species who are trying to harm you (van Valen, 1973; delightfully called the 'Red Queen hypothesis' after Lewis Carroll's character in Through The Looking Glass, who observed, 'Now, here, you see, it takes all the running you can do, to keep in the same place.') However, the benefits of bringing together useful genetic traits during sexual reproduction must be balanced by the possibility that already coexisting beneficial traits are separated among offspring (Desai and Fisher, 2007). By contrast, harmful genetic mutations—those that compromise evolutionary fitness—must be weeded out to prevent them from accumulating in a population (see 'Muller's ratchet', from Muller, 1964; also 'Kondrashov's hatchet', after Kondrashov, 1988).

The fitness advantages conferred by sexual reproduction explain its near-ubiquity among complex species. Indeed, even plants and simple animal species that typically reproduce asexually in stress-free environmental conditions to which they are comfortably adapted can switch to sexual reproduction during times of stress or environmental change, when genetic mixing may produce a survival advantage among offspring (for example, Becks and Agrawal, 2010). So successful an evolutionary strategy is sexual reproduction that many complex species, including humans, have completely lost the ability to reproduce asexually. No wonder Erasmus Darwin remarked that, 'Sexual reproduction is the chef d'oeuvre, the masterpiece of nature.' (Darwin, 1800).

Gametes and sexes While genetic exchange mechanisms exist, well-studied in bacteria and virus-host interactions, where DNA is transferred between different individuals in a non-sexual fashion (Callier, 2019), the evolutionary root of sexual reproduction via specialised gametes lies with the evolution of multicellularity, at least 1.5 billion years ago (Fu et al., 2019). In simple species like yeast (who can reproduce both sexually and asexually), all gametes are structurally similar; this is called 'isogamy'. However, successful gamete pairing and fusion may be limited by molecular compatibility—mediated by various proteins on the cell surface (for example, Lipke and Kurjan, 1992)—between the cells of the parents. Such compatibility groups are described as 'mating types', usually labelled by a system of numbers (for a primer on mating types, see Fraser and Heitman, 2003). The number of mating types within a species can be thousands, and they functionally promote genetic diversity within a population by preventing gamete fusion between genetically-similar parents. Isogamy is thought to be the ancestral state for sexual reproduction and remains common in simple sexually-reproducing species like yeast.

For an excellent overview of gamete evolution, see Lehtonen and Parker (2014) and references therein. Briefly, modelling of evolutionary scenarios for a variety of gamete characteristics shows that a binary system of gametes is optimal; that is, large gametes and small gametes, with gamete fusion occurring only between one small and one large gamete (not small-small or large-large fusions). We call this binary system of gamete fusion 'anisogamy'.

In species with two gamete types, the large gamete (and associated biology) is termed 'female' and the small gamete (and associated biology) is termed 'male'. In animals, the female and male gametes take the familiar forms of egg and sperm, respectively. In plants, the female and male gametes are contained in the ovules and pollen, respectively. That two different gametes form the optimal arrangement for sexual reproduction is understood in terms of gamete specialisation. The female gamete, with greater physical volume, single-handedly provides to the developing embryo basic cellular components, many molecules and signals required to direct early growth and energy-creating units called 'mitochondria'. Strict uniparental—specifically, maternal—inheritance of cellular components—commonplace in anisogamy—is presumed favourable for embryo health by eliminating any biological compatibility between mitochondria (Greiner et al., 2015) and eliminates wasting when both parents invest resources in these components. In contrast, the male gamete sacrifices contribution to offspring beyond the chromosomes contained in its nucleus. Male gametes in many species have typically become specialised for mobility to better access female gametes—consider the tail-like structures of sperm that propel it towards the egg (Lessels et al., 2009) and pollen grains sticking to bee legs (Hu et al., 2008)—and created in large numbers to improve the chances of both an encounter with a female gamete and the outnumbering of small gametes from other males (Parker and Lehtonen, 2014).

Anisogamy is the evolutionary origin of the two sexes—the reproductive roles associated with female or male gamete contributions to offspring. The evolution of gametes into two non-overlapping, morphologically-distinct types necessitates specific cellular and tissue systems to produce either one or the other gamete and favours the subsequent evolution of anatomy that facilitates successful fertilisation events. The evolution of separate sexes is thought to have arisen multiple times in plants and animals, suggesting an evolutionary benefit. Common explanations include higher individual fitness when an individual is specialised for a single reproductive role, rather than trying to balance resources between both male and female functions (Charnov, 1982). In fact, given differential gamete morphology, the subsequent divergence into two separate sexes of individuals has been described as, 'an almost inevitable consequence of sexual reproduction in complex multicellular organisms.' (Lehtonen and Parker, 2014). Extending from mere inevitability to essentiality of outcome, Kashimada and Koopman (2010) state that, 'the development of two sexes is observed in most animals and is essential for their survival and evolution.'

Why this almost inevitable divergence into just two sexes of individuals has occurred—repeatedly in evolutionary history—is the subject of much research. To answer this question, we must review the established knowledge on gamete evolution—the halving of genetic material, uniparental inheritance of intracellular components—and interrogate under what conditions could a third reproductive role—a third sex—evolve and what function could it have? Indeed, an exploration of this question was the prompt for the opening chapter quote. That is, 'No practical biologist interested in sexual reproduction would be led to work out the detailed consequences experienced by organisms having three or more sexes; yet what else should he do if he wishes to understand why the sexes are, in fact, always two?' (Fisher, 1930). And from science to science fiction, this question is, wonderfully, puzzled over by Kurt Vonnegut's Billy Pilgrim who, when considering the Tralfamadorians in Slaughterhouse-Five, surmised, 'They said their flying-saucer crews had identified no fewer than seven sexes on Earth, each essential to reproduction. Again: Billy couldn't possibly imagine what five of those seven sexes had to do with the making of a baby, since they were sexually active only in the fourth dimension. [...] It was gibberish to Billy.'

Sexual systems and bodies Across almost all complex life, there are precisely two types of gamete—and thus two and precisely two sexes. But this does not impose restrictions on how sex is allocated in different species. Evolutionary biologist Lukas Scharer illuminates, 'The male and female sexes are not two types of individuals; they actually represent two different reproductive strategies, and in many organisms, these two strategies are distributed among individuals in a population in a variety of ways.' (Scharer, 2017). That is, across the natural world, there is great diversity (and ingenuity, if one can—teleologically, of course—describe characteristics favoured by natural selection as 'ingenious') regarding the allocation of male and female sexes within and between individuals and across populations.

A 'sexual system' describes the physical and functional interactions of the two sexes at the individual and population level. We have learned that the evolution of separate sexes of individuals—a state called 'gonochorism'—is near-ubiquitous in animals; individuals within a gonochoristic species comprise two anatomic classes divided by reproductive role. Typically, male or female sex is fixed early in embryonic development and immutable to change during the lifespan of any individual, even though, of course, the physical characteristics associated with sex may be subject to expected age-related changes or changes acquired via injury or disease (or, at the hands of humans, surgery).

Humans cannot be hermaphrodites—individuals who fulfil both male and female reproductive roles in their lifespan—though hermaphroditism is a natural body plan in many anisogamous species. Many plants—particularly flowering plants—and (few) less complex animals exist as simultaneous hermaphrodites, with both female and male sexes manifested in the same flowers and/or same individual plant or animal at the same time of life. Many aquatic species—most notoriously, clownfish—are sequential hermaphrodites, where changes in reproductive role during the lifespan ('sex change') are evidenced by the switch from male to female (in the case of clownfish) or female to male gamete production, underpinned by anatomical changes in gamete-producing tissues (gonads). In the case of clownfish, this switch of sex (male to female) is driven by the loss of the single breeding female from the colony (Casas et al., 2016). Sequential hermaphroditism appears most common in species where males and females have the same excretory structures for eggs and sperm, and 'sex change' requires no or minimal remodelling of gross anatomy. For example, clownfish fertilisation is external, and male and female clownfish both have a similar ductal system that allows the sperm and eggs, respectively, into the aquatic environment. With highly-specialised and qualitatively-different reproductive anatomies, neither obviously nor easily remodelled post-development, 'sex change' in humans is impossible.

Evolution provides a dazzling array of anatomies and appearances. It is often true that gonochoristic males whose reproductive role is to contribute sperm have evolved appendages for direct introduction of that sperm into females, while the females of many species have evolved internal biology that receives sperm and, in the case of viviparous mammals who give birth to live young, protects the developing offspring from the outside world. But appearances can be deceptive. For example, male seahorses have a brood pouch in which developing baby seahorses are incubated, a functional role more usually associated in the natural world with female individuals. However, these seahorses are the sex class that contribute sperm to the offspring, and it is that, not their gross anatomy, which defines those individuals as male. Another curious example is that of female spotted hyenas, who have a hyper-enlarged clitoris that resembles a penis, yet they produce eggs that are fertilised by a male hyena and are, by definition, female. Human-centred biological expectations about anatomy, which include, for example, pregnancy in females and penile appendages in males are undoubtedly too narrow to capture the diversity of sexed bodies in the natural world.

Hermaphrodites incorporate both male and female sexes, and gonochorists one or the other. And while gonochorism and simultaneous hermaphroditism represent stable arrangements of the two sexes within a species, there are many that buck these trends in their individual composition. For example, there are species composed of females and hermaphrodites (McCauley and Bailey, 2009), of males and hermaphrodites (Weeks et al., 2009), and of males, females and hermaphrodites (Oyarzun et al., 2020). That is, the two sexes can be differentially-allocated in individuals and between species. Yet, despite the variety of bodies and sexual systems found in the natural world, their organisation around two and only two sexes is a fundamental feature. Reproduction within and between individuals occurs by the meeting of female and male gametes, one of each type, in that precise combination, in a pattern recapitulated across almost all complex life. The binary system of sex is an evolutionary thread stitched through life on earth.

HUMAN SEX

We have established what sex is, that sex describes reproductive role by reference to gamete type, and that there are—and can only be—two sexes. We have also described some of the fascinating manifestations of the two sexes within individuals and within populations. In this section, we turn to developmental biology—the study of how organisms grow and, increasingly, how they age—which is replete with examples of complexity of form built from simple biological principles. The development of the reproductive human is one such instance.

The developmental biology underpinning this section is largely sourced from standard reference textbooks in the field. Readers may also wish to explore Baresi and Gilbert’s Developmental Biology (online at the National Centre for Biotechnology Information) and Wolpert’s Principles of Development.

Making a baby Humans are mammals and are—like almost all animals—divided into two classes of individuals according to reproductive role. In humans, the act of reproduction itself requires, in the first instance, male sperm to fertilise female eggs, achieved during intercourse between two sexually mature people. Male reproductive anatomy includes testes, contained in a sac of skin called the ‘scrotum’, that make sperm, delivered to the outside world through the penis. Both testes and penis are external organs, housed outside the male body, while female reproductive anatomy is almost wholly internal. It comprises ovaries that periodically release mature eggs, collected by the nearby oviducts (also called Fallopian tubes) and transported towards the uterus, the hollow muscular organ in which, in the event of a successful fertilisation event, a baby will grow. The uterus connects, via the cervix, to the vagina, which exits the body at the vulva, incorporating the clitoris and the urethral opening, surrounded by folds of skin called labia.

During intercourse, male sperm is mixed with water and lubricants from the seminal vesicles and prostate gland (to create semen), and the penis delivers the resulting semen into the female body via ejaculation. Semen moves through the cervix and uterus to the oviducts, where, should a mature egg be ready, fertilisation occurs. The fertilised egg is transported then implanted into the uterine wall, and commences development proper - at this stage, the female is pregnant. In the absence of a successful fertilisation event, the female body, having already prepared a blood-rich, spongey uterus lining suitable for implantation, breaks down this lining and expels it via the vagina during menstruation. In humans, gestation—the growing of a baby within the pregnant female uterus—lasts around nine months, after which the female gives birth, typically via the vagina (although surgical interventions like caesarean section, where the baby is removed via an incision through the uterus wall, may be necessary in negative medical circumstances or elected as a preference).

Sex determination Reproductive anatomy develops in utero, in a series of complicated yet elegant anatomical steps. The first step in reproductive development, however, is the determination of the future sex of a new embryo: female or male? In humans, sex is genetically-determined at fertilisation via the XY determination system of sex chromosomes. Females possess two X chromosomes, while males possess one X and one Y, with the Y chromosome carrying male-specific genes that activate male development. Given that sex chromosomes, like all other pairs of chromosomes, are divided individually when gametes are made, each human egg contains one X chromosome (and females are called 'homogametic') while human sperm contains either an X or Y chromosome (with males termed 'heterogametic'). Offspring sex is thus dependent on whether an egg receives, at the moment of fertilisation, either an X or Y chromosome from the sperm.

The pattern of chromosomes within an individual is called a 'karyotype'. Like all chromosomes, sex chromosomes carry genes. In humans, a key sex-determining gene is called SRY (sex-determining region Y) and it is, in genetically-healthy individuals, carried by the Y chromosome (Kashida and Koopman, 2010; Sinclair et al., 1990). The protein product of the SRY gene acts as a 'master switch' for male development, initiating a cascade of molecular genetic signals that drives the first anatomical step towards a sexed human body, gonad differentiation.

Embryonic development Gonad differentiation occurs at around six weeks in utero, when a bipotential pair of gonads—small buds of tissue in the abdominal cavity—are triggered to differentiate into ovaries or testes, the gamete-producing tissues in females and males, respectively. XY embryos carrying a functional SRY gene will trigger differentiation of testes via a network of molecular signals; in the absence of SRY activity, XX embryonic gonads begin to differentiate into ovaries, activating distinct molecular signals for that developmental pathway (Lecluze et al., 2020; Mamsen et al., 2017). There is feedback between these differentiation pathways; for example, a signal required for ovarian development—and the later maturation of eggs—also suppresses early testes differentiation (Jaaskelainen et al., 2010).

In embryological terms, gametes do not originate in the growing gonads. Rather, specialised stem cells migrate into the differentiating gonad region where they are embedded as the precursor cells that will ultimately become eggs or sperm, depending on gonad type (Magnusdottir and Surani, 2014). Ongoing gonad development into mature egg- or sperm-producing tissues relies on the differentiation of sex-specific gonad cell types, a process requiring tissue-specific hormone action. However, gonad differentiation into ovaries or testes also directs, via that sex-specific hormone milieu each generates, downstream events in reproductive anatomy development coordinated with future gamete type. That is, ovaries fated to produce eggs will direct ongoing female development and testes fated to produce sperm will direct ongoing male development. In this sense, gonads can be considered as organiser tissues, coordinating the development of a reproductive system that integrates future gamete type with relevant reproductive anatomy; the absence of future gamete function—infertility—is no barrier to understanding the sex of human.

The first embryonic targets of gonadal organisation, from around eight weeks in utero, are two pairs of ducts running alongside the gonads called the paramesonephric and mesonephric ducts, which will grow into female or male internal genitalia, respectively. Both female and male embryos develop both pairs of ducts in early development; after gonadal differentiation, sex-specific hormonal action promotes growth of one pair over the other. Male testes secrete two major hormones that act upon these pairs of ducts. Testosterone promotes the growth of the mesonephric duct into male internal genitalia, and secreted anti-Mullerian hormone triggers degeneration of the paramesonephric duct, thus eliminating the duct that would develop into female internal genitalia. In females, the presence of ovaries means there is little testosterone to promote growth of mesonephric duct structures, nor anti-Mullerian hormone to trigger degeneration of paramesonephric duct structures. The female hormone environment thus permits growth of female internal genitalia, while the mesonephric duct (and the potential for male internal genitalia) degenerates.

The second embryonic target of gonadal organisation, from around 10 weeks in utero, is the development of external genitalia. The external genitals—vagina, clitoris and labia in females and prostate, penis and scrotum in males—derive from shared precursor tissues called the genital tubercle and urogenital fold. Under the influence of sex-specific gonadal hormones, these tissues are moulded into male or female form. Specifically, a derivative of testosterone (dihydrotestosterone) is produced locally—from testosterone—in the precursor tissues in males, and this derivative is a potent inducer of male external genitalia. In the converse situation, low testosterone and low dihydrotestosterone in females permits this precursor tissue to develop into female external genitalia. Given that male and female external genitalia develop from the same embryonic tissue under differential hormonal influences, analogous structures can be identified: the clitoris and penis share many structural features, while the labia represents an unfused version of the scrotum.

The sex of a newborn baby is routinely and reliably observed at birth by visual and palpable (‘touch’) assessment of external genitalia. Increasingly, the sex of a baby is identified in utero by observation of external genitalia or detection of sex chromosome karyotype/SRY gene presence. This is a matter of observation, woefully mischaracterised by the term ‘assignment’. The language of ‘assignment’ has been co-opted from serious medical decision-making in the case of clinical pathologies of the reproductive system (discussed below).

Puberty and secondary sex characteristics The development of reproductive anatomy in utero is called ‘primary sex development’, and the outcome is a body that has the potential to fulfil the male or female reproductive role. Human sex development undergoes a second phase of development at puberty, between the ages of 10-18 years old. This phase of secondary sex development generates divergence between the body shapes of females and males—a phenomenon called ‘sex dimorphism’—that has evolved under selection pressure to increase one’s likelihood of mating, following two broad strategies: be the most attractive or the most dominant. Both females and males gain height and bone density, experience the onset of libido, and experience typical teenage symptoms like acne and body odour. Under the influence of sex-specific gonadal hormones, female reproductive anatomy matures, ovulation and menstruation commence, hip width increases, and breast tissue develops, in preparation for future motherhood. As well as experiencing male-typical maturation of reproductive anatomy (increase in testes volume and penile length), males gain greater height than females, grow facial hair, develop deeper voices, broader shoulders, and acquire far larger amounts of skeletal muscle than females.

Atypical sex development We have described the typical reproductive anatomy and sequence of events during development in healthy human beings. However, as a system with multiple biological inputs, steps and components, atypical or pathogenic development of reproductive anatomy can occur; in short, there are many points at which reproductive development can go awry. Collectively, medical conditions resulting from atypical reproductive development are called disorders (or, in patient-facing language, differences) of sex development (DSDs). There are around 40 known DSDs occurring in humans, most a result of mutations in genes required for the healthy development of reproductive anatomy in utero (Arboleda et al., 2014). The category of DSDs is broad, and it spans simple anatomic and hormone differences in otherwise healthy individuals to disorders with acute clinical sequelae that can cause postnatal harm or even death, and that need ongoing management throughout life.

Historically, DSDs have been described by terms such as 'hermaphroditism' and—currently falling into disuse—'intersex'. These terms are now deemed clinically-inaccurate and stigmatising to patients. Current nomenclature to categorise DSDs references karyotype and gonad status. Thus, the overarching categories are sex chromosome DSDs, XY DSDs and XX DSDs. For example, sex chromosome DSDs are exemplified by Turner syndrome and Klinefelter syndrome, where patients have irregular numbers of sex chromosomes and develop along typical female and male developmental trajectories, respectively, but experience hormonal issues that compromise sexual maturation and fertility. Other DSDs include conditions where female embryos are exposed to excessive testosterone in utero and develop an enlarged clitoris (an XX DSD called congenital adrenal hyperplasia) or where male embryos fail to produce the dihydrotestosterone required for penis growth (an XY DSD called 5 alpha reductase deficiency). Excellent resources on DSDs and their developmental etiology have been compiled, in collaboration with expert clinicians, by the UK charity DSD Families, and are available at their website.

The frequency of DSDs in the general population is the subject of much misinformation. Fausto-Sterling and her associates have defined as 'intersexual' any deviation from 'ideal, Platonic' male and female bodies, and arrived at a frequency of 1.7% of the population (Blackless et al., 2000; Fausto-Sterling 2000). Such a loose definition of DSDs captures a large number of people with no biologically-meaningful ambiguity of sex in any aspect of their development (most egregiously, the vast majority of this reported frequency are unambiguous females, often mothers, who have late-onset adrenal hyperplasia and, at some point post-birth, experience elevated testosterone levels as a result of an adrenal problem). This frequency of 1.7% was revised by Hull and Fausto-Sterling (2003) who, after identifying numerous flaws in the original studies, like failing to account for the sex-specific nature of many DSDs, revised the frequency to 0.4% of the population.

When assessing DSD frequency rationally restricted only to those individuals with ambiguous sexual anatomy or who exhibit a disparity between their reproductive (gondal) sex and external genitalia, the original frequency of 1.7% drops dramatically down to approximately 0.018 percent (Sax, 2002). That is, despite atypical sex development, almost all people are identifiable as either female or male. Within modern medicine, workflows to identify internal genitalia, karyotype and hormonal profiles exist to identify sex in ambiguously-presenting people, and understanding DSDs within the framework of typical developmental trajectories of females and males aids not only diagnosis of these clinical disorders but also informs prognostic decisions regarding management of specific conditions in terms of sexual function and fertility prospects. Nonetheless, the inflated frequency of 1.7% is routinely-cited as definitive (for example, by Amnesty in 2018).

SEX MYTHS

In 2021, in a letter published in the Irish Journal of Medical Science (the official organ of the Royal Academy of Medicine in Ireland), we argued that, ‘Public discourse around sex increasingly seeks to deny basic facts of human biology.’ (Hilton and Wright et al, 2021). The driver of this anti-science movement is gender identity ideology, which claims that a privately held identity regarding one’s sex is the ultimate definer of one’s sex. That is, if a person identifies (in some internal, unverifiable sense) as female or male, that person literally is female or male. The overarching aim of gender identity ideologists is to deny that sex—reproductive role and associated characteristics—exists as a natural biological category. The intent behind such a belief appears to be to undermine the common scientific understanding and validity of viewing females and males as discrete biological categories in favour of a wholly subjective and unfalsifiable categorisation scheme based on one’s personal and internal sense of self—gender identity. In this section, we will critique emerging misunderstanding, real or contrived, around sex.

Myth: sex is a composite score of body parts Underpinning ideological misrepresentations about sex is the conflation of sex (what is female?) with the physical characteristics associated with sex (how do we recognise female people?). That is, sex is not presented as anatomical patterns that develop in a co-ordinated fashion within the framework of an evolved function but as a checklist of seemingly-independent physical characteristics. This is often explicit; a Nature (2018) editorial asserted sex is, ‘a classification based on internal and external bodily characteristics.’ in a piece that failed to mention reproduction, the function of sex, or why humans have sexed bodies. And failed to acknowledge the obvious follow-up question: a classification based on internal and external bodily characteristics in which species? Of course, the reference species is assumed human, a peculiarly self-centred view of a biological phenomenon common to almost all complex life. In this sense, the conflation of sex with characteristics associated with sex retrospectively requires the redefinition of sex in every species on earth deploying anisogamy as a means of reproduction, while ignoring the unifying features shared by all.

Writing for The Skeptic in 2021, Hearne accurately defines ‘female’ as, ‘organisms whose gametes are [...] ova or eggs.’ yet immediately follows with, ‘Unless you are a fertility doctor, it’s unlikely you will encounter too many ova, so we must be using other definitions in everyday life.’ While it is true that gamete type is not directly assessed in strangers, it does not follow that we use alternative ‘definitions’ when identifying the sex of a person; more accurately, we use alternative sex characteristics, those that arise from the organisational effects of the gonads (which also dictate gamete type) during primary and secondary development. Hearne claims that features like external genitalia—routinely covered—and breast size—plumped by bras—are insufficient to identify the sex of a stranger, and that we do so by features such as, ‘amount and distribution of muscle and fat, the length and distribution of hair, the height and so on.’ This is true; in fact, psychiatrist Nirao Shah, who studies behavioral differences between males and females, considers, ‘correctly identifying [...] sex [is] a fundamental decision animals make.’ (Goldman, 2019). Alongside basic assessments of body shape like shoulder and hip width, humans are expert with faces; sex identification is, ‘an automatic and effortless aspect of face perception' triggering differential brain activity (Kaul et al., 2011). Intriguingly, females are consistently better than males at recognising female faces, even in the absence of (often) gendered cues like hair length (for example, Lewin and Herlitz, 2002). Humans also assess movement like walking gait in sex identification (Pollick et al., 2005). However, none of these data points is, as Hearne's logic would have it, a 'definition' of sex, in the same way that observing the texture and density of a rock allows us to identify it as igneous, where 'igneous' is defined as a rock generated from volcanic lava.

Changing the definition of sex from function to form—explicit in pieces with titles like 'Sex Redefined' (Ainsworth, 2015) and where function is often discarded as irrelevant—is a necessary foundation upon which the deconstruction of sex as a biological category is built. Following the redefinition of sex as a checklist of physical characteristics, claims regarding variability of characteristics can flourish, along two lines of argument. First in line are those people with DSDs who have atypical reproductive development. The description of sex characteristics in people with DSDs sometimes disaggregates a reproductive system into constituent parts like 'genetic sex', 'gonad sex', and so on, to better understand incongruent features, clinical management and prognostic outcomes in people with DSDs (for example, Arboleda et al., 2016). For nearly all people, these constituent parts are aligned—or at least not divergent in any meaningful way—and disaggregation has no utility. If such disaggregation can be considered useful, it is not in the redefinition of female and male sexes, but in the refinement of workflows that generate a complete clinical picture for those people with DSDs. However, since the coining of 'gender identity' by John Money in the 1960s, component parts of sex have occasionally included concepts of 'psychological' and 'social' sex (Moore, 1968), paving the way for 'identity' to be considered a sexed characteristic.

The second line of argument evokes those sex characteristics, like height and hormone levels, that can overlap between the sexes, to attempt to demonstrate that there is no clear boundary between the female and male sexes in humans, and that, 'there is no one parameter that makes a person biologically male or female.' (Elsesser, 2020). The aim here is to destabilise the established categories of female and male. It is, of course, true that, for example, many females are taller than many males, or that some males have low levels of testosterone more typical of the female sex. However, such arguments fail to acknowledge an elephant in the room—we can only know that males are typically taller and have higher testosterone levels than females if we have a means to divide and measure humans by sex, independent of height and testosterone level. And it is centuries of knowledge accrued by the study of sex as a functional property of a species, and the anatomic/molecular organisation of the human species around that evolved function, that serves as that reference point. Put simply, it would be impossible to claim that low and high testosterone levels are correlated with being female and male, respectively, unless the categories female and male already had established meanings that testosterone levels were being correlated with. And the same holds for every other sex correlate.

Myth: sex is not binary Having remapped the definition of sex from function to form, introduced exceptions—arising from clinical disorders—to Fausto-Sterling's 'Platonic ideal', and attempted to blur category boundaries in healthy humans with trivial observations of naturally-overlapping sex characteristics, various commentators have attacked the phenomenon of sex as a binary system, often failing—deliberately or otherwise—to understand what the term 'binary' means when applied to sex. Writing for the Guardian in 2015, Heggie claims 'binary sex' means, 'the idea that there are men and women and they can be clearly distinguished.' (Heggie, 2015). Cade Hildreth (2022) claims that, 'sex is not binary because people cannot be grouped into two separate, non-overlapping groups.' These are straw man arguments.

The functional system of sex is routinely-described as 'binary' (including, on many occasions, by us). The use of 'binary'—meaning, 'of, pertaining to, characterised by, or compounded of, two' (Oxford English Dictionary)—in this context intends to indicate, simply, a biological system with two components, and follows the same etymological pattern by which, for example, a system composed of two stellar masses is described as a binary star. Use of the word 'binary' operates at a system level across all species employing anisogamy.

However, having constructed a straw man argument that sex in humans is not binary, rejection of the term 'binary' is extended into rejection of 'two' itself, and the substitution of ideological framings of sex that move the conversation far from biological reality. Many interlocutors posit quantitative descriptions of sex as the necessary alternative to categorical descriptions. The most common quantitative (continuous) data distribution used to frame sex is a bimodal distribution, whereby various quantifiable traits associated with sex, such as adult height and testosterone levels, are conceptualised as multiple, overlapping distributions. These overlapping distributions of individual traits are purported to generate two modes that represent the average or typical female and male (as described by a combination of their average or typical sex characteristics), while shoulders for each mode permit for variation of sex characteristics. Routinely plotted on a horizontal axis crudely labelled 'sex', this framework gives rise to the premise that one's sex is a statistical score generated by measuring multiple quantifiable characteristics. For a widely-circulated conceptualisation of 'bimodal sex', Hildreth (2022) describes the modes as, 'peaks in a graph [that] represent probability clusters.' Further to claims that sex is bimodal are claims that, 'The science is clear—sex is a spectrum.' (Brusman, 2019), an expression of a continuous distribution that replaces modes with, in the words of Brusman, 'unlimited options.' The corollary is that the sex of every human is unique to that individual, or, in the words of Fausto-Sterling when considering The Five Sexes, Revisited (2000), 'Rather than identify a specific number of sexes [...] sex and gender are best conceptualized as points in a multidimensional space.'

The outcome of categorising sex as the sum of continuous descriptions of sex traits is that every person is scored as some percent male or female. The often-denied logical progression of such scoring is that a male with lower than average testosterone, petite stature, or a smaller than average penis, is shifted away from the male mode towards the female mode (typically occupied by people with low testosterone, petite stature and no penis). Such males, by this framework, are scored as 'more female' than counterparts with average or high testosterone, great stature and large penises. These damaging judgments equally extend to females with enlarged clitorises, small breasts or increased musculature, who, by the above logic, are scored as 'more male' than their larger-breasted and less athletic counterparts.

As sex within a continuous framework becomes a matter of sliding people left or right towards and from typical female and male, the middle of this distribution is cast as the no man's land where—plus ça change—people with DSDs are placed. For those with little comprehension of DSDs beyond vague imaginings that people with DSDs have 'both sets' of genitals, this is intuitive. However, DSDs do not present as random combinations of primary and secondary sex organs, and neither do they simply differ by degree from one another. Rather, DSDs represent dozens of conditions with unique etiologies that manifest in disparate ways. There is no single medical category that is 'intersex' nor is there a robust method of ordering them, as would be necessary of a quantitative/continuous distribution of sex. Attempts to order categories of DSD into some continuous distribution are doomed to fail—entirely reasonably—if one cannot order basic properties like sex chromosome conformation or gonad type within a continuous distribution (for example, Montanez, 2017).

Myth: sex is a social construct The spider's web of arguments touched upon here—and including the occasional reminder that sex development is very complicated (Sun, 2019), as if scientists are not well-trained in dissecting complexity to understand fundamental principles—culminates with the premise that the biological categories of sex are constructed by humans. Butler (1990) writes, 'Perhaps this construct called 'sex' is as culturally constructed as gender.' While it is true that scientists observing the natural world develop language and models to describe the natural world, one cannot credibly argue that the phenomena themselves are constructed by humans. If that were the case, not only have humans invented sex but they have also invented stars, gold, clouds and penguins. We have seen that sex is a fundamental property of almost all complex life, and its evolutionary existence pre-dates the human capacity to describe it.

The argument that sex is socially- or culturally-constructed settles, then, at the boundaries between sex categories, and the asserted arbitrariness straddling a fuzzy boundary (an important 'proof' that sex is not observed but 'assigned' at birth). However, the assertion that the categories of male and female are arbitrary because some rare individuals may present with ambiguous sexual anatomy is like asserting that the two different sides of a coin are arbitrary because there exists a non-zero probability a coin may land on its edge. The fact that sex may be ambiguous for some does not call everyone's sex into question. The categories described in humans by 'female' and 'male' are stable, functional, and the dividing line has emerged from observation of our (and other) species, not a coin toss.

Myth: biologists have alternative understandings about sex Finally we challenge the premise that some new scientific consensus on sex has emerged. Writing for German news site DW, Sterzik (2021) claims, 'Yet the broad scientific consensus now looks different: sex is a spectrum.' The definitions and understandings of sex we present in the first two sections of this chapter are uncontroversial, appearing in dictionaries, key biology textbooks and medical consensus statements like that issued by the Endocrine Society (Barghava et al., 2021). There is a vast literature which depends, explicitly or implicitly, on these understandings of sex. Searches on the scientific publication database PubMed for "male" [AND] "sperm" or "female" [AND] "egg"—that is, not exhaustive searches—retrieve around 100,000 results each, including numerous and recent publications from Nobel Laureates in Physiology or Medicine, and from a huge array of biological and medical disciplines.

Furthermore, searches (performed on 9th July 2022) for phrases like 'bimodal sex', 'sex is bimodal', 'spectrum of sex', 'sex is a spectrum' or 'sex is a social construct' generates no results in the biological or medical literature, although two close matches for 'sex is a spectrum' are returned. The first is a study of how sex—female or male—affects the spectrum of genetic variations acquired in the X chromosome over a lifespan (Agarwal and Przeworski, 2019). The second is a study of fetal sex—female or male—affects the spectrum of placental conditions experienced during pregnancy (Murji et al, 2012). Neither study demonstrates any confusion—quite the opposite—about the nature of sex, and both exemplify the importance of understanding sex in a clinical setting. Although not an exhaustive search, it seems that claims of a new scientific consensus—or, at minimum, an academic divide amongst biologists—regarding sex are rather overblown. Such claims are simple appeals to authority, absent from the scientific literature and apparently manufactured by public commentators.

CONCLUSIONS

In this chapter, we have seen that the most prevalent mechanism of reproduction in complex species has stabilised on a binary system of differential gamete types, and the subsequent evolution of body types around this binary system. The majority of species, including humans, are composed of individual females and males, defined by reproductive role, describing their contribution of large, energy-rich gametes (like eggs) or small gametes (like sperm), respectively, to the next generation.

In humans, notwithstanding atypical reproductive development, there are two evolved anatomical body types, each corresponding to one of the two reproductive functions. In utero, females and males develop sex-specific primary characteristics pertinent to reproduction, in the first instance the differentiation of gonad type that will direct future female or male function. Gonads—ovaries or testes, determined in humans by genetic mechanisms—are responsible for both the development of mature gametes (eggs or sperm) and, via hormones, the coordinated development of the relevant reproductive system. In adults, male anatomy comprises testicles, internal genital structures like the vas deferens, and an external penis and scrotum. Female anatomy comprises internal ovaries, internal genital structures like a uterus and vagina, and an external vulva incorporating the clitoris.

Finally, we have dissected arguments that attempt to challenge these basic understandings of sex. We have revealed that the redefinition of sex from an integrated, anatomical system organised around an evolutionary function to a checklist of human-centred, disaggregated physical characteristics is the foundation on which variability of those physical characteristics (in natural or pathological development) is used to deconstruct sex as a binary system, rendering it a construct of the human mind and, if it suits one's political aims, meaningless. We reject such arguments as purely ideological, with no evidence they are taken seriously in the scientific community, lacking explanatory power, and ultimately spurious. Despite the offered alternative frameworks to describe sex, the foundation that is the binary system shines through, underpinning the bimodal peaks of traits or dictating with which other 'point in multidimensional space' a person can successfully reproduce.

REFERENCES

Agarwal, I. and Przeworski, M. (2019). Signatures of replication timing, recombination, and sex in the spectrum of rare variants on the human X chromosome and autosomes. PNAS, 116(36), pp17916-17924.
Ainsworth, C. (2015). Sex redefined. Nature, 518, pp288–291.
Amnesty. (2018). Intersex awareness day: 5 myths [online]. Available at https://www.amnesty.org/en/latest/news/2018/10/its-intersex-awareness-day-here-are-5-myths-we-need-to-shatter/ [accessed 8th August 2022].
Arboleda, V. A. et al. (2014). DSDs: genetics, underlying pathologies and psychosexual differentiation. Nat Rev Endocrinol, 10(10), pp603-615.
Baresi, M. J. F. and Gilbert, S. F. (2020). Developmental Biology. Oxford: Oxford University Press; www.ncbi.nlm.nih.gov/books/NBK9983
Barghava, A. et al. (2021). Considering Sex as a Biological Variable in Basic and Clinical Studies: An Endocrine Society Scientific Statement. Endocrine Reviews, 42(3), pp219–258.
Becks, L. and Agrawal, A. (2010). Higher rates of sex evolve in spatially heterogeneous environments. Nature, 468(7320), pp89–92.
Bell, G. (1982). The masterpiece of nature: The evolution and genetics of sexuality. Berkeley: University of California Press.

Blackless, M. et al. (2000). How sexually dimorphic are we? Review and synthesis. Am J Hum Biol, 12, pp151–166.
Brusman, L. (2019). Sex isn't binary, and we should stop acting like it is [online]. Available at https://massivesci.com/articles/sex-gender-intersex-transgender-identity-discrimination-title-ix/ [accessed 9th August 2022].
Butler, J. P. (1990). Gender trouble: Feminism and the subversion of identity. Abingdon: Routledge.
Callier, V. (2019). Core Concept: Gene transfers from bacteria and viruses may be shaping complex organisms. PNAS, 116 (28), pp13714-13716.
Carroll, L. (1871). Through the looking-glass and what Alice found there. London: Macmillan Publishers.
Casas, L. et al. (2016). Sex change in clownfish: molecular insights from transcriptome analysis. Sci Rep, 6, pp35461.
Charnov, E. L. (1982). The theory of sex allocation. Princeton: Princeton University Press.
Darwin, C. (1859). On the origin of species by means of natural selection, or, the preservation of favoured races in the struggle for life. London: John Murray Publishing.
Darwin, E. (1800). Phytologia: Or, the philosophy of agriculture and gardening. London: Joseph Johnson Publishing.
Davis, W.M., and Uhrin, M. (1991). It Has Been Said. Perspect Biol Med, 34(4), pp549-552.
Desai, M. M. and Fisher, D. S. (2007). Beneficial mutation–selection balance and the effect of linkage on positive selection. Genetics, 176(3), pp1759-1798.
DSD Families [online resource]. Available at https://dsdfamilies.org [accessed 9th August 2022].
Elsesser, K. (2020). 'The myth of biological sex'. Forbes, June 15th, 2020.
Fausto-Sterling, A. (2000). The five sexes: Revisited. Sciences (New York), 40(4), pp18-23.
Fisher, R. A. (1930). The genetical theory of natural selection. Oxford: Clarendon Press.
Forstater, M. (2021). Sex, gender, and medical data. BMJ, 372, n735.
Fraser, J. A. and Heitman, J. (2003). Fungal mating-type loci. Curr Biol, 13(20), R792-795.
Fu, C. et al. (2019). Genetic and genomic evolution of sexual reproduction: echoes from LECA to the fungal kingdom. Curr Opin Genet Dev, 58-59, pp70–75.
Goldman, B. (2019). Animal magnetism [online]. Available at https://stanmed.stanford.edu/2019spring/brains-hard-wired-recognize-opposite-sex.html [accessed on 9th August 2022].
Greiner, S. et al. (2015). Why are most organelle genomes transmitted maternally? Bioessays, 37(1), pp80–94.
Hearne, S. (2021). Species, Individual, Gender—biology and taxonomy don't deal in black and white [online]. Available at https://www.skeptic.org.uk/2021/03/species-individual-gender-biology-and-taxonomy-dont-deal-in-black-and-white/ [accessed 9th August 2022].
Heggie, V. (2015). 'Nature and sex redefined – we have never been binary'. Guardian, February 19th, 2015.
Hildreth, C. (2022). The gender spectrum: A scientist explains why gender isn't binary [online]. Available at https://cadehildreth.com/gender-spectrum/ [accessed 9th August 2022].
Hilton, E. and Wright, C. (2020). 'The Dangerous Denial of Sex'. Wall Street Journal, February 13th 2020.
Hilton, E. and Wright, C. et al. (2021). The reality of sex. Ir J Med Sci, 190(4), pp1647.
Hu, S. et al. (2008). Early steps of angiosperm–pollinator coevolution. PNAS, 105(1), pp240-245.
Hull, C. L. and Fausto-Sterling, A. (2003). Response to: How sexually dimorphic are we? Review and synthesis. Am J Hum Biol, 15(1), pp112-115.
Jaaskelainen, M. et al. (2010). WNT4 is expressed in human fetal and adult ovaries and its signaling contributes to ovarian cell survival. Mol Cell Endocrinol, 317(1-2), pp106-111.

Kashimada, K. and Koopman, P. (2010). Sry: the master switch in mammalian sex determination. Development, 137(23), pp3921–3930.
Kaul, C. et al. (2011). The gender of face stimuli is represented in multiple regions in the human brain. Front Hum Neurosci, 4, pp238.
Kondrashov, A. S. (1988). Deleterious mutations and the evolution of sexual reproduction. Nature, 336(6198), pp435-440.
Lecluze, E. et al. (2020). Dynamics of the transcriptional landscape during human fetal testis and ovary development. Hum Reprod, 35(5), pp1099-1119.
Lehtonen, J. L. and Parker, G. A. (2014). Gamete competition, gamete limitation, and the evolution of the two sexes. Mol Hum Reprod, 20(12), pp1161-1169.
Lessells, C.M. et al. (2009). The evolutionary origin and maintenance of sperm: selection for a small, motile gamete mating type. In Birkhead, T. R., Hosken, D. J. and Pitnick, S. eds Sperm Biology: An Evolutionary Perspective. London: Academic Press, pp43-67.
Lewin, C. and Herlitz, A. (2002). Sex differences in face recognition--women's faces make the difference. Brain Cogn, 50(1), pp121-128.
Lipke, P. N. and Kurjan, J. (1992). Sexual agglutination in budding yeasts: structure, function, and regulation of adhesion glycoproteins. Microbiol Rev, 56(1), pp180–194.
Maddrell, S. H. (1998). Why are there no insects in the open sea? J Exp Biol, 201(17), pp2461-2464.
Magnusdottir, E. and Surani, M. A. (2014). How to make a primordial germ cell. Development, 141(2), pp245–252.
Mamsen, L.S. et al. (2017). Temporal expression pattern of genes during the period of sex differentiation in human embryonic gonads. Sci Rep, 7, pp15961.
Maynard Smith, J. (1978). The evolution of sex. Cambridge: Cambridge University Press.
McCauley, D. E. and Bailey, M. F. (2009). Recent advances in the study of gynodioecy: the interface of theory and empiricism. Ann Bot, 104(4), pp611-620.
Montanez, A. (2017). Visualizing sex as a spectrum [online]. Available at https://blogs.scientificamerican.com/sa-visual/visualizing-sex-as-a-spectrum/ [accessed 9th August 2022].
Moore, K. L. (1968). The sexual identity of athletes. JAMA, 205(11), pp787-788.
Muller, H. J. (1932). Some genetic aspects of sex. Am Nat, 66, pp118–138.
Muller, H. J. (1964). The relation of recombination to mutational advance. Mutat Res, 106, pp2-9.
Murji, A. et al. (2012). Male sex bias in placental dysfunction. Am J Med Genet A, 158A(4), pp779-783.
Nature. (2018). US proposal for defining gender has no basis in science. Nature, 563, pp5.
Oyarzun, P. A. et al. (2020). Trioecy in the marine mussel Semimytilus algosus (Mollusca, Bivalvia): stable sex ratios across 22 degrees of a latitudinal gradient. Front Mar Sci, 7, pp348.
Parker, G. A. and Lehtonen, J. L. (2014). Gamete evolution and sperm numbers: sperm competition versus sperm limitation. Proc R Soc B, 281, pp20140836.
Pollick, F. E. et al. (2005). Gender recognition from point-light walkers. J Exp Psychol Hum Percept Perform, 31(6), pp1247-1265.
Pubmed [online resource]. Available at https://pubmed.ncbi.nlm.nih.gov [accessed 9th August 2022].
Sax, L. (2002). How common is intersex? A response to Anne Fausto-Sterling. J Sex Res, 39(3), pp174-178.
Scharer, L. (2017). The varied ways of being male and female. Mol Reprod Dev, 84(2), pp94-104.
Sinclair, A. H. et al. (1990). A gene from the human sex-determining region encodes a protein with homology to a conserved DNA-binding motif. Nature, 346, pp240-244.

Sterzik, K. (2021). Why sex and gender aren't binary issues [online]. Available at https://www.dw.com/en/why-sex-and-gender-arent-binary-issues/a-57062033 [accessed 9th August 2022].
Sun, S. D. (2019). Stop using phony science to justify transphobia [online]. Available at https://blogs.scientificamerican.com/voices/stop-using-phony-science-to-justify-transphobia/ [accessed 9th August 2022].
van Valen, L. (1973). A new evolutionary law. Evol Theory, 1, pp1–30.
Vonnegut, K. (1969). Slaughterhouse-five, or the children’s crusade. New York: Delacorte Publishing.
Weeks, S. C. et al. (2009). Evolutionary transitions among dioecy, androdioecy and hermaphroditism in limnadiid clam shrimp (Branchiopoda: Spinicaudata). J Evol Biol, 22(9), pp1781-1799.
Wizemann, T. M. and Pardue, M. L. (2001). Exploring the Biological Contributions to Human Health: Does Sex Matter? Washington: National Academies Press.
WHO. (2022). WHO updates its widely-used gender mainstreaming manual [online]. Available at https://www.who.int/news/item/06-07-2022-who-updates-widely-used-gender-mainstreaming-manual [accessed 9th August 2022].
WHO. Health topics/Gender [online]. Available at https://www.who.int/europe/health-topics/gender#tab=tab_1 [accessed 9th August 2022].
Wolpert, L. et al. (2019). Principles of Development. Oxford: Oxford University Press.

BIOGRAPHIES

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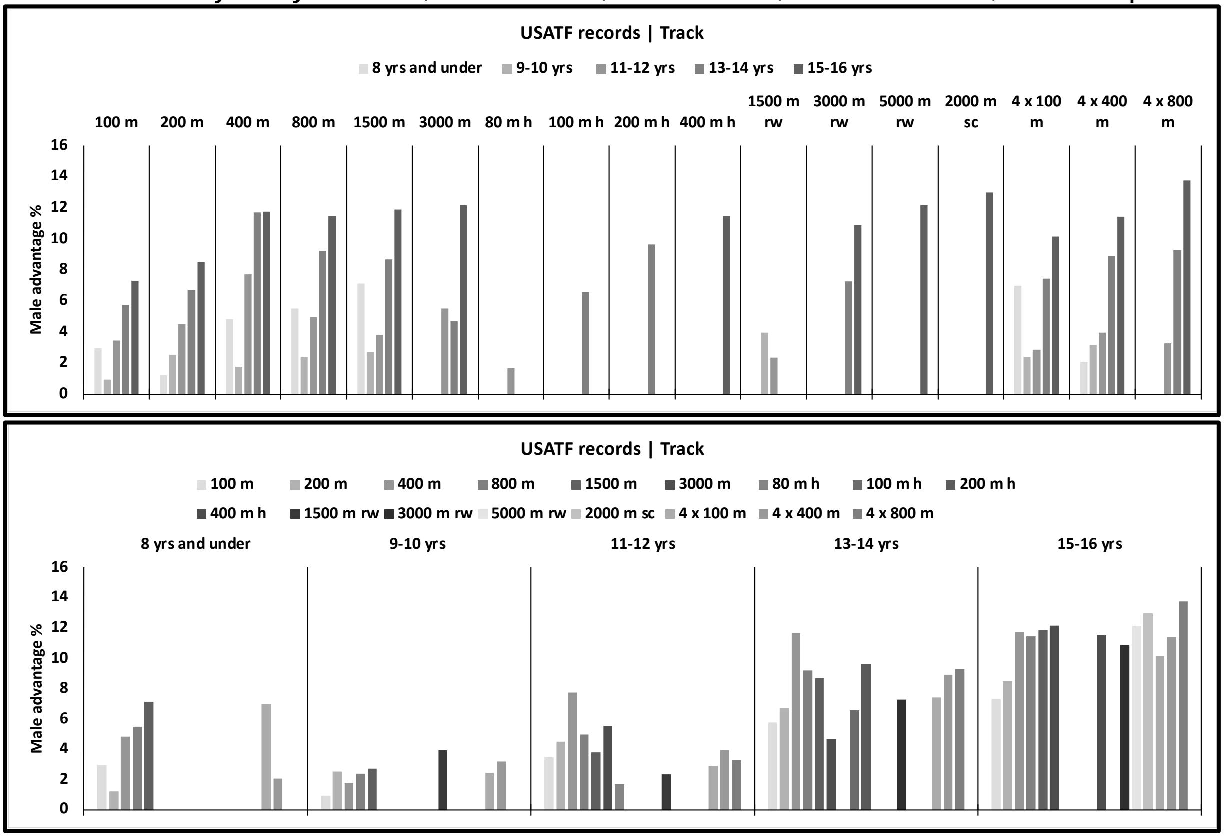
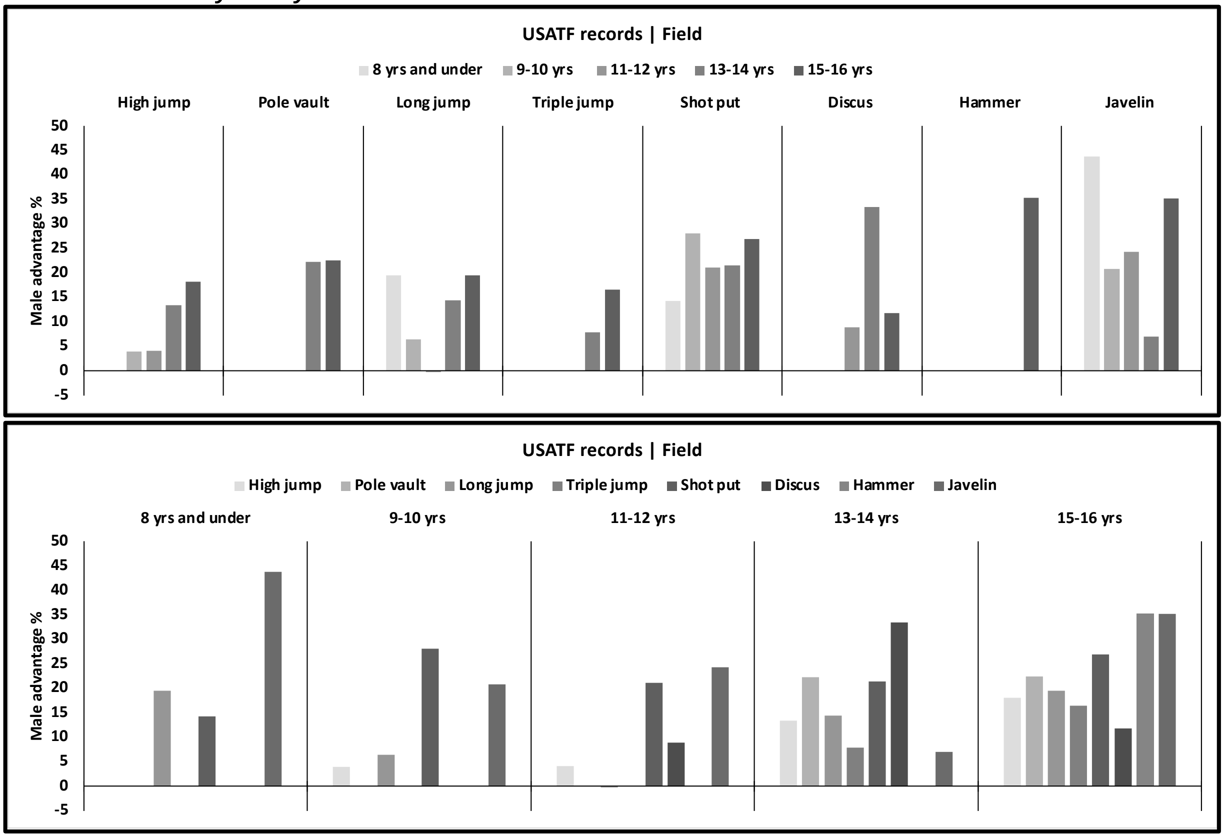
Appendix 3.
USATF junior records from 8-16 years old; analysis of male performance advantage.

Figure A3.1. The male advantage over females in USATF schoolchildren records in track events, stratified by event (upper panel) and age group (lower panel).
Abbreviations: yrs – years old, m – metres, h – hurdles, rw – racewalk, sc - steeplechase



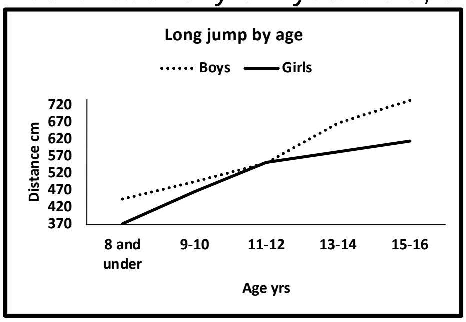
Male advantage is evident in all track events at all ages.

Figure A3.2. The male advantage over females in USATF schoolchildren records in field events, stratified by event (upper panel) and age group (lower panel).
Abbreviations: yrs – years old



Male advantage is evident in all field events at all ages, except long jump/11-12 years old (female advantage 0.2%).

Figure A3.3. Age progression in the long jump in USATF schoolchildren records.
Abbreviations: yrs – years old, cm - centimetres



For long jump at 11-12 years old, female advantage is explained by the convergence of slightly poor male performance and good female performance; perhaps due to pubertal growth spurt in female athlete.

Figure A3.4. Male versus female "wins" in USATF schoolchildren records, scored in track events (upper panel) and field events (lower panel).
Abbreviations: yrs – years old, m – metres, h – hurdles, rw – racewalk, sc - steeplechase

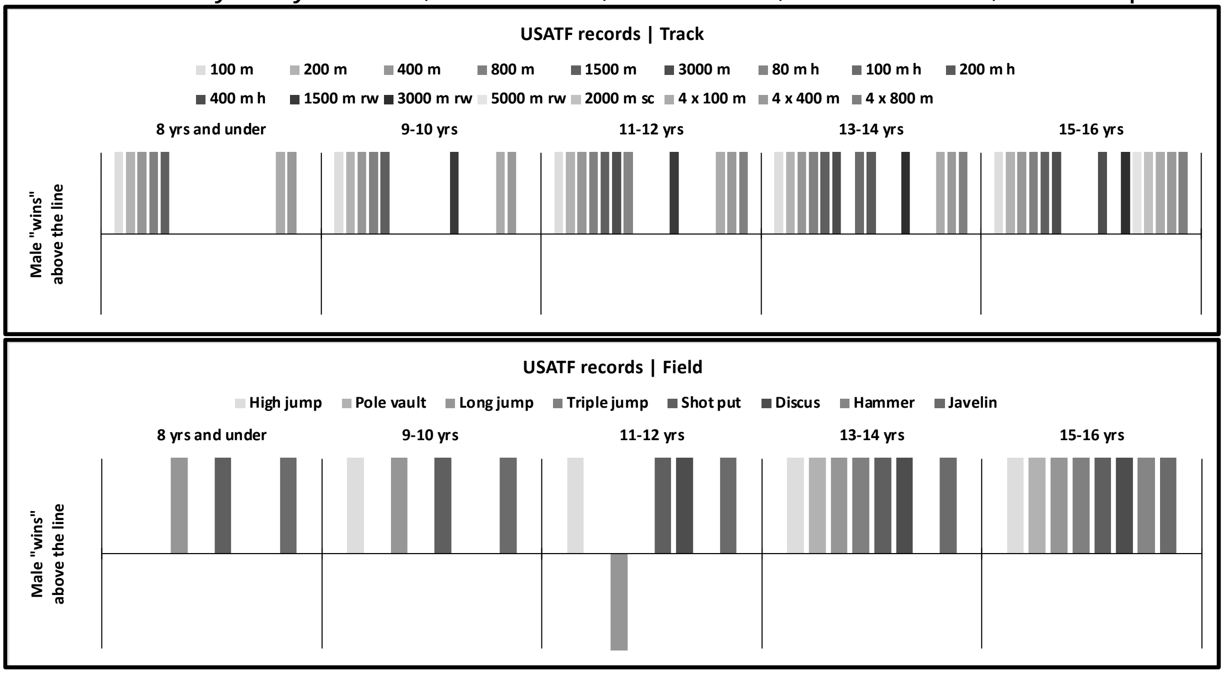
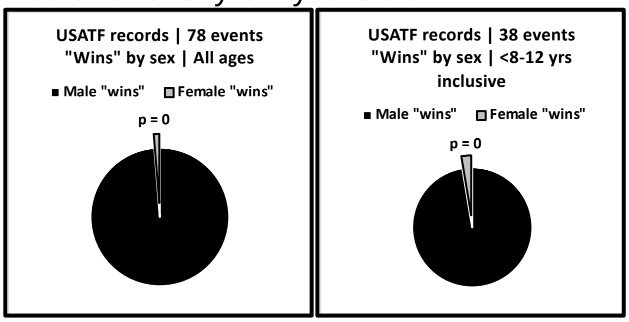


Figure A3.5. The frequency of male versus female "wins" across pooled events in all age groups (left) and limited to pre-puberty age groups (right).
Abbreviations: yrs – years old

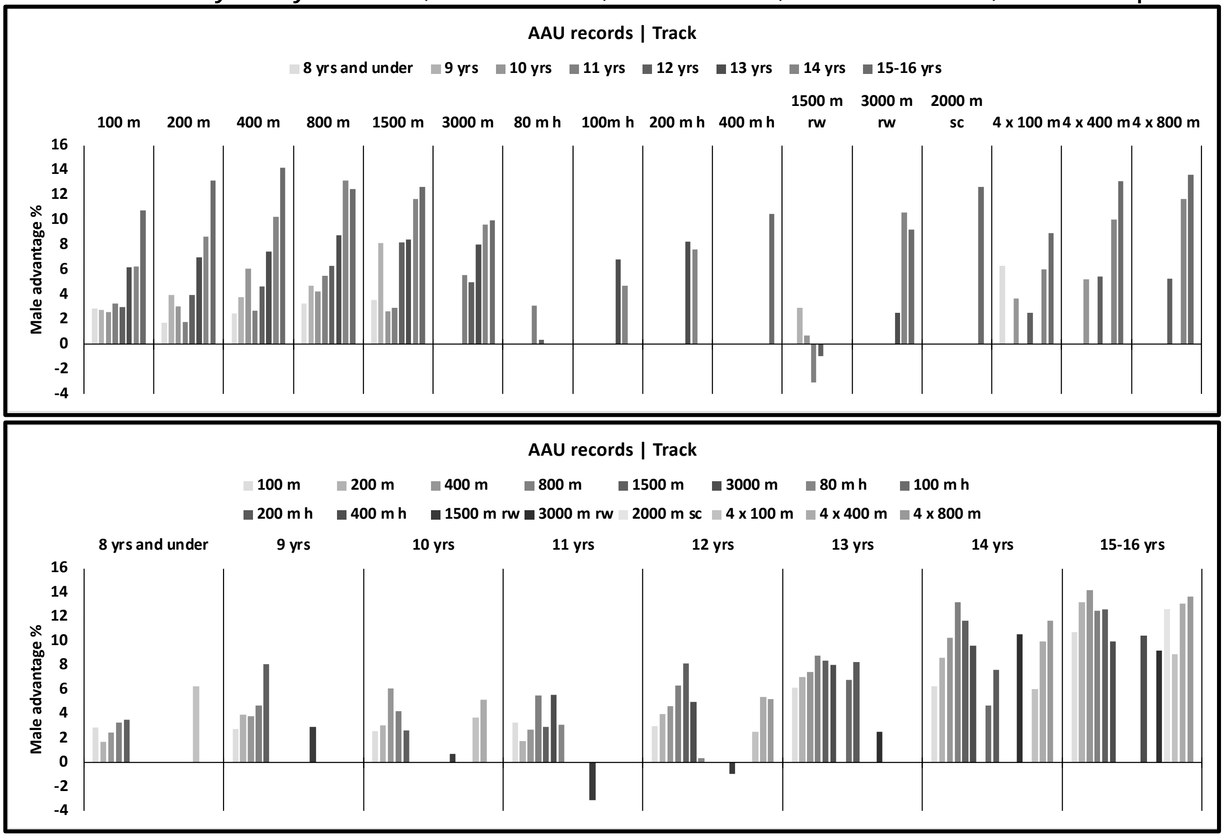


The probability of this frequency of male "wins" occurring by chance, either at all ages or limited to pre-puberty ages, is calculated at as effectively zero (p = 0).

Conclusions from USATF junior record analysis:
1. male advantage over female peers is evident across track and field events from 8 years old onwards.
2. males systematically outperform their female peers from 8 years old, at a frequency that is vanishingly unlikely to result from chance.

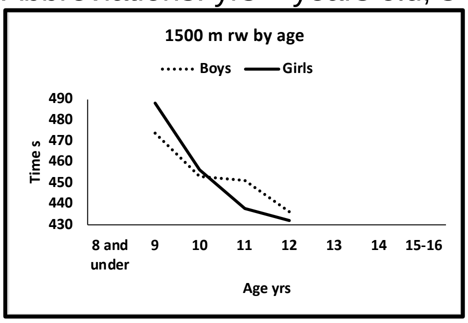
Appendix 4.
AAU junior records from 8-16 years old; analysis of male performance advantage.

Figure A4.1. The male advantage over females in AAU schoolchildren records in track events, stratified by event (upper panel) and age group (lower panel).
Abbreviations: yrs – years old, m – metres, h – hurdles, rw – racewalk, sc – steeplechase



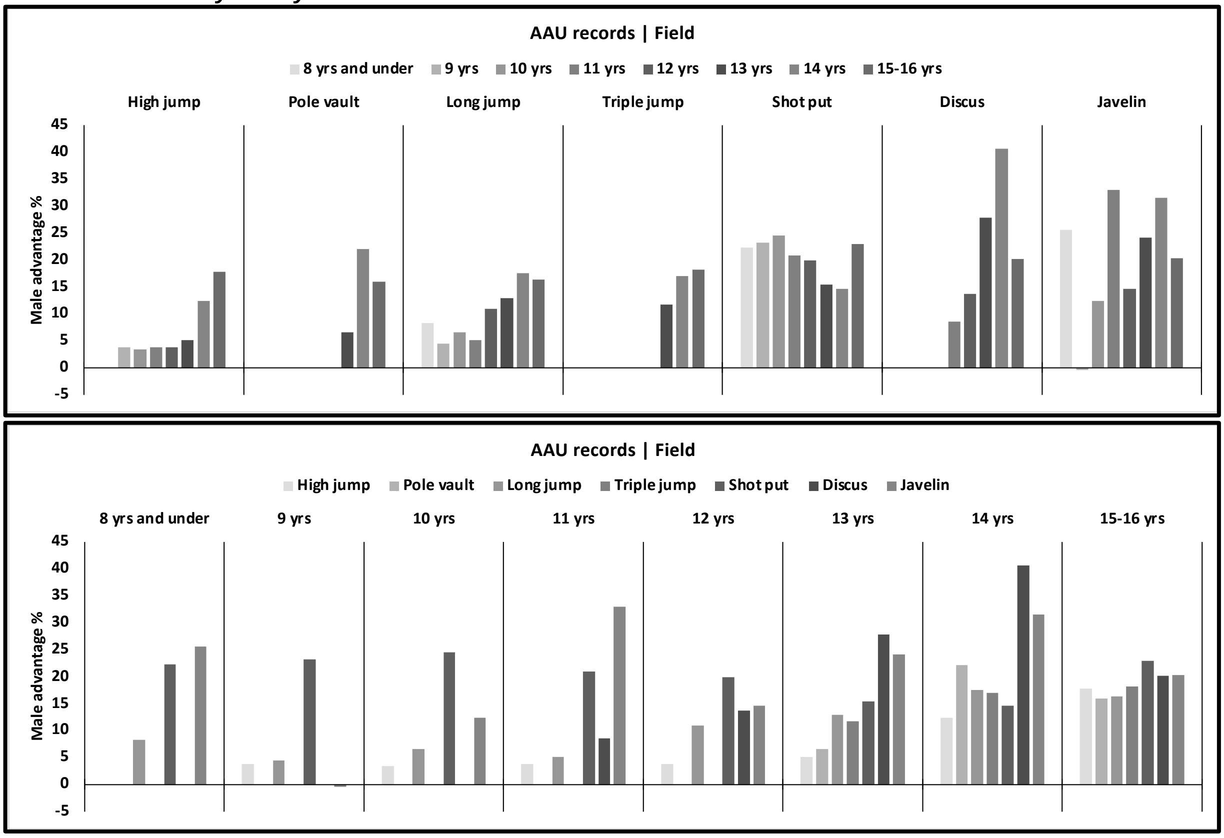
Male advantage is evident in all track events at all ages, except 1500 m rw/11 years old (female advantage 3.1%) and 12 years old (0.9%).

Figure A4.2. Age progression in the 1500 m rw in AAU schoolchildren records.
Abbreviations: yrs – years old, s - seconds



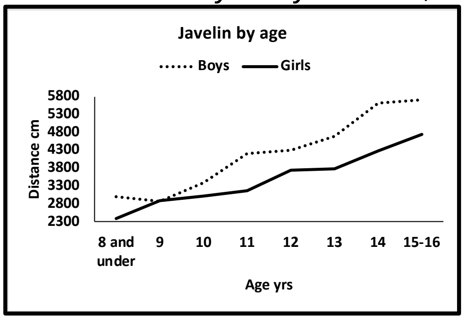
For the 1500 m rw at 11 years old and 12 years old, female advantage is underpinned by good female performances, perhaps explained by pubertal growth spurt synergising with the hip and joint flexibility required for racewalking. This female advantage is transient, and not evident in older age groups in the 3000 m rw event.

Figure A4.3. The male advantage over females in AAU schoolchildren records in field events, stratified by event (upper panel) and age group (lower panel).
Abbreviations: yrs – years old



Male advantage is evident in all field events at all ages, except javelin/9 years old (female advantage 0.4%).

Figure A4.4. Age progression in the javelin in AAU schoolchildren records.
Abbreviations: yrs – years old, cm - centimetres



For javelin at 9 years old, female advantage may be explained by unexpectedly poor male performance converging with good female performance.

Figure A4.5. Male versus female "wins" in AAU schoolchildren records, scored in track events (upper panel) and field events (lower panel).
Abbreviations: yrs – years old, m – metres, h – hurdles, rw – racewalk, sc - steeplechase

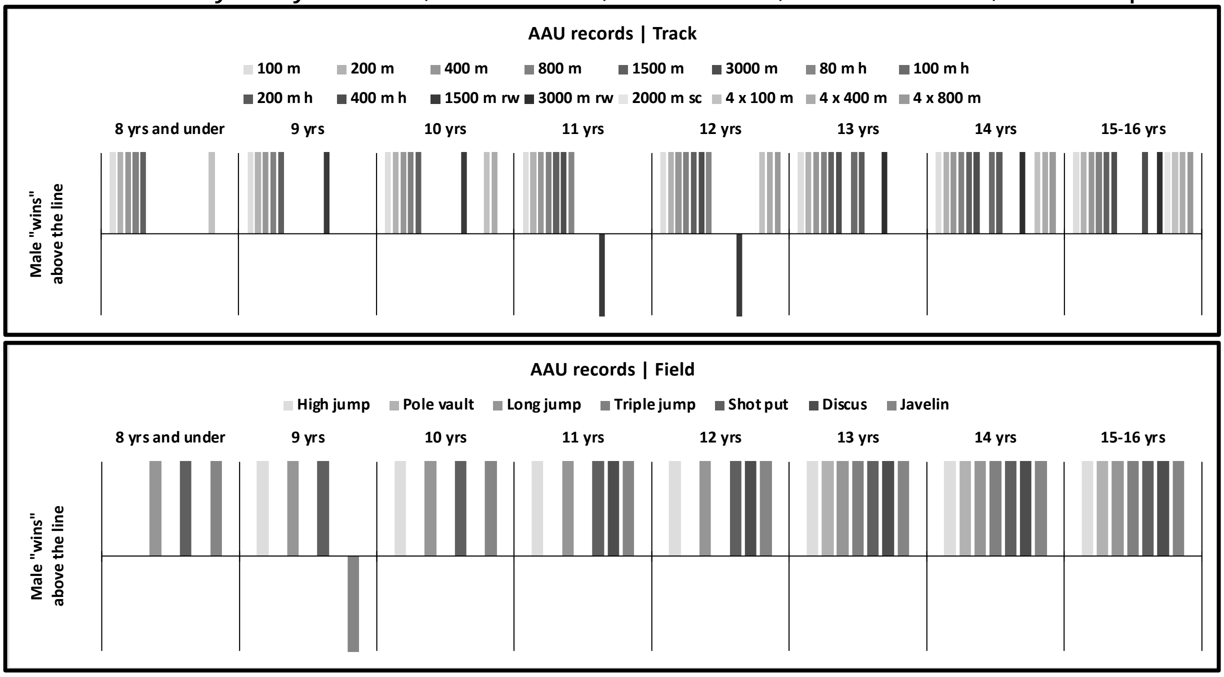
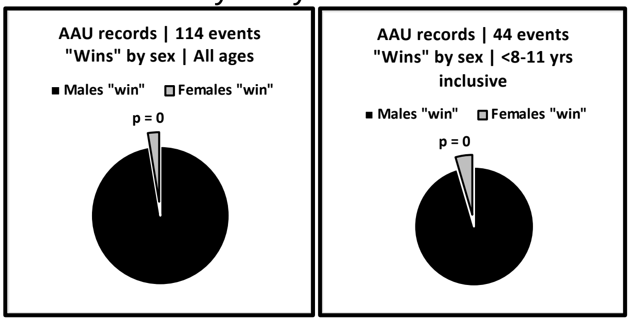


Figure A4.6. The frequency of male versus female "wins" across pooled events in all age groups (left) and limited to pre-puberty age groups (right).
Abbreviations: yrs – years old

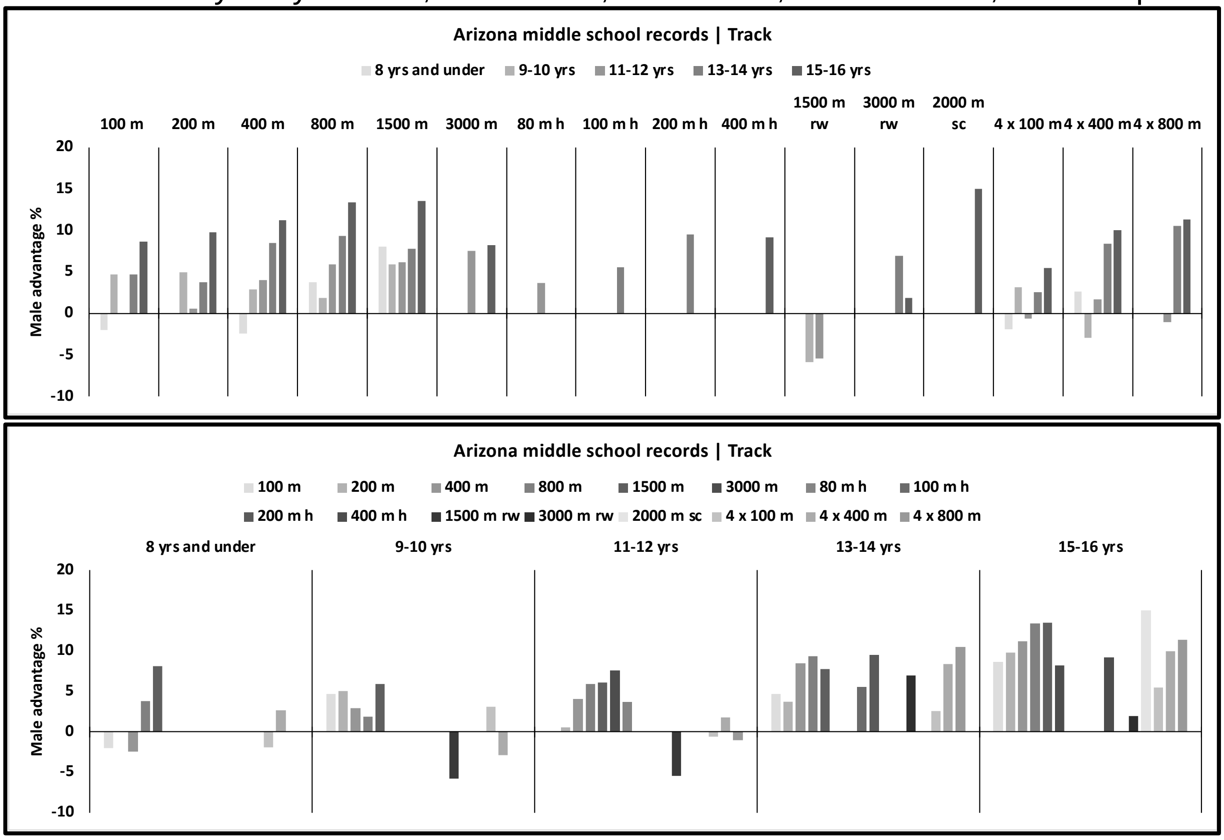


The probability of this frequency of male "wins" occurring by chance, either at all ages or limited to pre-puberty ages, is calculated at as effectively zero (p = 0).

Conclusions from AAU junior record analysis:
1. male advantage over female peers is evident across track and field events from 8 years old onwards.
2. males systematically outperform their female peers from 8 years old, at a frequency that is vanishingly unlikely to result from chance.

Appendix 5.
AZ middle school records from 8-16 years old; analysis of male performance advantage.

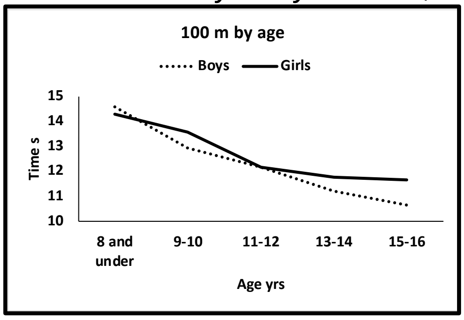
Figure A5.1. The male advantage over females in AZ middle school records in track events, stratified by event (upper panel) and age group (lower panel).
Abbreviations: yrs – years old, m – metres, h – hurdles, rw – racewalk, sc – steeplechase



Male advantage is evident in most track events at all ages. Female advantage was calculated in 9 events:

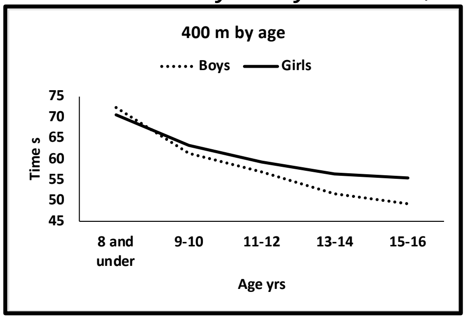
Event	Age group	Female advantage %
100 m	8 yrs and under	2.0 %
	11-12 yrs	0.0 % (same record)
400 m	8 yrs and under	2.4 %
1500 m rw	9-10 yrs	5.8 %
	11-12 yrs	5.4 %
4 x 100 m	8 yrs and under	1.9 %
	11-12 yrs	0.6 %
4 x 400 m	9-10 yrs	2.9 %
4 x 800 m	11-12 yrs	1.1 %

Figure A5.2. Age progression in the 100 m in AZ middle school records.
Abbreviations: yrs – years old, s - seconds



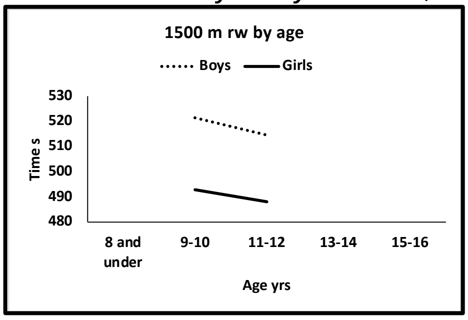
For 100 m at 8 years old and under, in the absence of a preceding datapoint, it is impossible to analyse the apparent female advantage here. The dead heat at 11-12 years old may be explained by good female performance; perhaps due to pubertal growth spurt in female athlete.

Figure A5.3. Age progression in the 400 m in AZ middle school records.
Abbreviations: yrs – years old, s - seconds



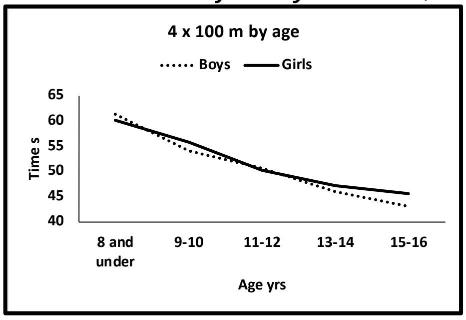
For 400 m at 8 years old and under, in the absence of a preceding datapoint, it is impossible to analyse the apparent female advantage here.

Figure A5.4. Age progression in the 1500 m rw in AZ middle school records.
Abbreviations: yrs – years old, s - seconds



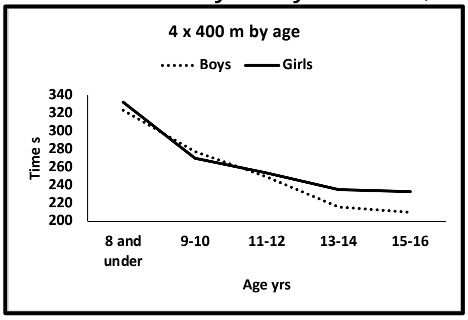
For the 1500 m rw at 9-10 years old and 11-12 years old, female advantage is likely underpinned by good female performances, perhaps explained by pubertal growth spurt synergising with the hip and joint flexibility required for racewalking. This female advantage is transient, and not evident in older age groups in the 3000 m rw event.

Figure A5.5. Age progression in the 4 x 100 m in AZ middle school records.
Abbreviations: yrs – years old, s - seconds



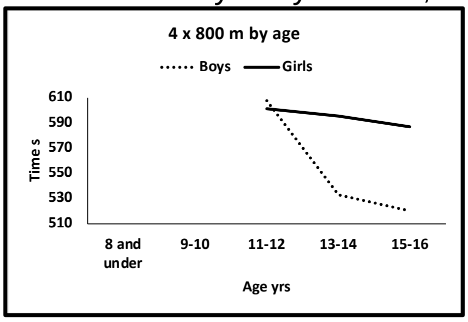
For 4 x 100 m at 8 years old and under, in the absence of a preceding datapoint, it is impossible to analyse the apparent female advantage here. The female advantage at 4 x 100 m/11-12 years old may be explained by good female performance; perhaps due to pubertal growth spurt in females.

Figure A5.6. Age progression in the 4 x 400 m in AZ middle school records.
Abbreviations: yrs – years old, s - seconds



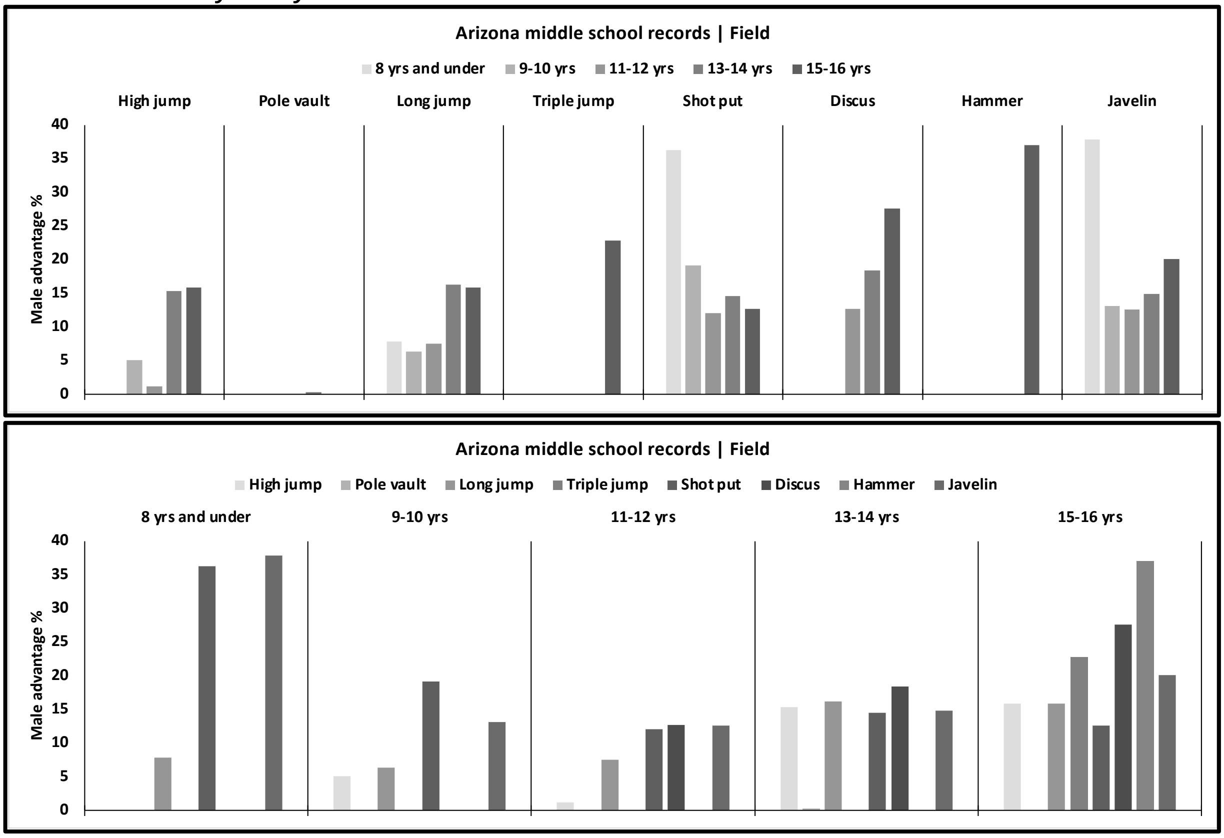
The female advantage at 4 x 400 m at 9-10 years old may be explained by good female performance; perhaps due to pubertal onset.

Figure A5.6. Age progression in the 4 x 800 m in AZ middle school records.
Abbreviations: yrs – years old, s - seconds



For 4 x 800 m/11-12 years old and under, in the absence of a preceding datapoint, it is impossible to analyse the apparent female advantage here. However, the unusually-steep male trajectory to 13-14 years old indicates the female advantage at 11-12 years old is likely underpinned by unexpectedly poor male performance.

Figure A5.7. The male advantage over females in AZ middle school records in field events, stratified by event (upper panel) and age group (lower panel).
Abbreviations: yrs – years old



Male advantage is evident in all field events at all ages

Figure A5.8. Male versus female "wins" in AZ middle school records, scored in track events (upper panel) and field events (lower panel).
Abbreviations: yrs – years old, m – metres, h – hurdles, rw – racewalk, sc - steeplechase

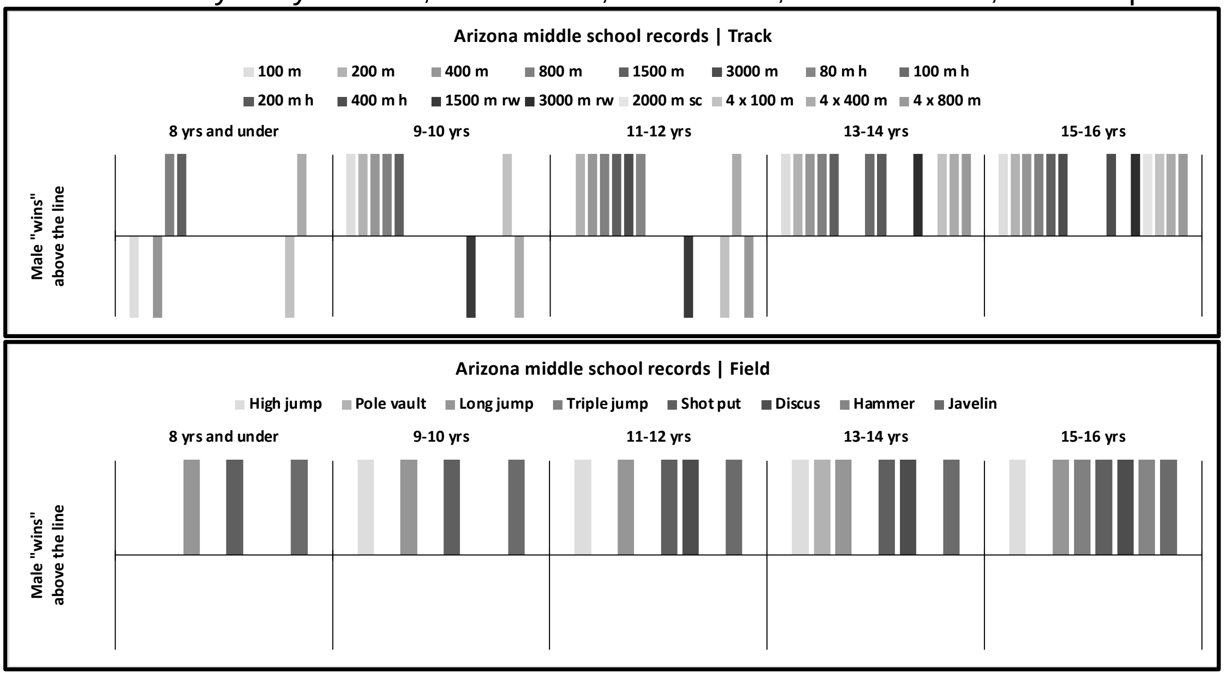
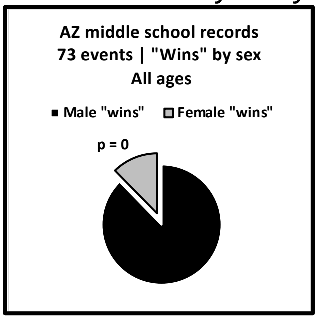
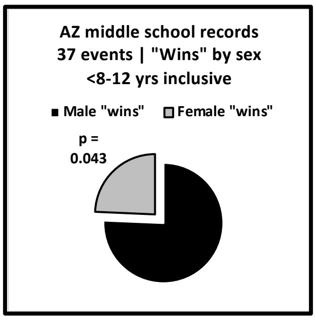


Figure A5.9. The frequency of male versus female "wins" across pooled events in all age groups (left) and limited to pre-puberty age groups (right).
Abbreviations: yrs – years old





The probability of this frequency of male "wins" occurring by chance at all ages is calculated at as effectively zero (p = 0). The probability of this frequency of male "wins" occurring by chance at pre-puberty ages is calculated as p = 0.043, where p > 0.05 represents the threshold of statistical significance in this test. Note: the dead heat in 100 m at 11-12 years old was scored as a female win, to faithfully test the limits of this analysis.

Conclusions from AZ middle school record analysis:
1. male advantage over female peers is evident across track and field events from 8 years old onwards.
2. males systematically outperform their female peers from 8 years old, at a frequency that is unlikely to result from chance.

EXHIBIT 5

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Attorneys for Defendant Thomas C. Horne

UNITED STATES DISTRICT COURT

DISTRICT OF ARIZONA

Jane Doe, by her next friends and parents Helen Doe and James Doe; and Megan Roe, by her next friends and parents, Kate Roe and Robert Roe, **Plaintiffs,** **v.** **Thomas C. Horne, in his official capacity as State Superintendent of Public Instruction, *et al.*,** **Defendants.**	**Case No. 4:23-cv-00185-JGZ** **DECLARATION OF DR. LINDA BLADE, Ph.D, IN SUPPORT OF DEFENDANT HORNE'S RESPONSE TO PLAINTIFFS' MOTION FOR PRELIMINARY INJUNCTION**

I, Linda Blade, declare as follows:

I submit this expert declaration based upon my personal knowledge.

If called to testify in this matter, I would testify truthfully based on my expert opinion.

QUALIFICATIONS

As a former Canadian Champion (1986) and a full-scholarship NCAA All American (1984) in Track & Field (heptathlon) out of the University of Maryland (1982-1985), I worked hard to be a top student. Academic honors included being named Provost Scholar and member of Phi Beta Kappa.

Now licensed as a Chartered Professional Coach by the Coaches of Canada Association with a PhD in Kinesiology (earned in 1994), I have worked for over 30 years as a "Sport Performance Professional" coaching hundreds of athletes from 5 to 70 years of age, beginner to elite, from many different sports: track & field, hockey, soccer, volleyball, basketball, rugby, triathlon, sailboat racing, football, tennis, squash, swimming, diving, gymnastics, figure skating, skiing and bobsledding.

In my profession as a coach, I blend concepts in human biology with practical coaching methods acquired through many years of personal learning and mentorship opportunities as both athlete and coach. The unique way that I integrate theory and practice has proven to be highly effective. Many top athletes have sought my assistance at various times along their pathway to excellence. At the elite level, I have worked with National Hockey League (NHL) professional players (Edmonton Oilers dryland training, 2016-2018), mentored a world-leading female triathlete (Paula Findlay, 2009-2010) and helped train Pairs Figure Skaters, Jamie Salé and David Pelletier, to an Olympic Gold Medal (2002, Salt Lake City).

Truthfully, though, my greatest accomplishment as a coach has been working with beginners; young athletes ages 6 to 12 years.

It started during my first summer vacation after my freshman year in university. Needing a summer job that would be near the track where I had to continue training, I decided to offer a community "Run, Jump, Throw" camp for kids. Over 200 showed up and seemed to enjoy my coaching. Hosting that camp as a private enterprise became my summer job for consecutive years of college. I learned how to train children and how to help them improve movement skills that would lay a strong athletic foundation for future success in sports.

Almost a decade after those early years of coaching, my life took an interesting turn. I had finished my PhD in Kinesiology with a subspecialty that focused on measurement of physical growth and development of children (anthropometry), and I was stationed in northern Nigeria (West Africa) at the location that is predominantly Islamic. (This is the same region where the Islamic militant group Boco Haram operates.)

The main university in that region is Bayero University, Kano (BUK). I got my first faculty position there in the Department of Physical Education. Admittedly, it was a bit strange to have a Canadian woman (me) teaching courses, including track and field activity courses, to prospective teachers at one of the top centers of Islamic Studies in Africa.

World Athletics got wind of this situation all the way over in Monaco and suddenly I was recruited (1993) by the CEO of World Athletics' global coaching development, Bjorn Wangemann. His plan was to train and send a world-leading female instructor (me) into Islamic countries to teach women how to coach young girls. There was, of course, a need in religiously segregated places to have female instructors deliver the global coaching certification programs.

This is how I came to be teaching the World Athletics Level 1 (for beginners) coaching curriculum in various countries during the 1990s: in Bahrain, Puerto Rico, Guyana, Kenya, and Sri Lanka.

The highlight of that experience was the course I taught in Iran in July of 1995. I was sent into Tehran to deliver the World Athletics certification course to 30 of the top female coaches selected from across that country. I was the first Western woman since Ayatollah Khomeini's 1979 revolution to travel to Iran for the purpose of engaging women and girls in sport.

For me, personally, that trip to Iran was a wakeup call. I witnessed firsthand what life is like when women & girls are not respected nor given the same rights as men and boys in society. Navigating the "opportunity gaps" in search of training spaces where I could teach the women without male interference was unbelievably challenging. It showed me how vulnerable women's rights can be, including the severely limited access that women can have to their own sporting experiences. I vowed to never again take such things as Title IX and open access to women's opportunities for granted. I could see that what women in the West have achieve in sports is historically unique and politically fragile.

In 1997 a story about my travels as a global coaching instructor appeared in Sports Illustrated.[i]

Once becoming a mother (1998) and I settled down to a life of coaching in Edmonton, Alberta. Almost immediately, I was approached (1999) by a leading authority in Canadian Track & Field with a special request to author a curriculum piece for basic athletics instruction of children ages 5-11. The timing was perfect. I poured every bit of knowledge I had acquired as top athlete, scholar of child growth, academic instructor, and global coaching lecturer into the Athletics Canada "Run, Jump, Throw" (RJT) program (2001).[ii] Eventually, the rights to that RJT program were purchased by the Hershey's Track and Field Youth Program (2007). A video describing the RJT program can be found here: https://www.youtube.com/watch?v=TQMEg2D0TTw.

More recently, I have authored an update to the RJT program for children called the "Mini Legends Program." [iii]

In 2014, after years of developing children's sports programs and coaching hundreds of athletes at all levels of expertise, I became nominated and voted into office as President of the Board at Athletics Alberta - the track and field association for the province of Alberta. It was while attending national meetings as president in 2018 that I became aware of a philosophy that seeks to allow male athletes to self-identify into female competitions. I could see in an instant that this would be a catastrophe for female athletes.

Throughout my professional career, I have always maintained that it is unfair for males to compete with females at any age. I believe it is a clear example of discrimination on the basis of sex.

My argument as to why female children should have their own category will now be explained.

REASONS WHY PRE-PUBESCENT GIRLS DESERVE FEMALE-ONLY SPORTS

A few items require clarification before I delve into my rationale.

A. Terminology - For the sake of clarity in my usage of language I will use biological terminology to reflect sex, which is the key determinant of physical reality and performance. For a male-born child I use the word "boy" and pronouns "he/him" (irrespective of social identity). Likewise, for the female-born child I must use the word "girl" and pronouns "she/her."

B. Age delimitation - Since puberty onset can happen as early as nine years of age in some children (especially in girls, who mature on average two years earlier than boys) any comparison of boys and girls deemed to be strictly "pre-pubertal" must be delimited to data obtained at eight years of age and earlier. Therefore, any references I make to data collection and results for prepubertal school children will focus on the 6- to 8-year-old range.

C. Data artifact – In the age range of 9-11 years, due to the phenomenon I mention above, some of the top girls can appear to be "catching up" to the boys in measures of fitness and sport performance. Charts often show a narrowing of the sex differences during this age range. This narrowing of differences between boys and girls is a temporary outlier that arises from the early maturation of a few girls. It is important to note that this phenomenon does not happen for *all* girls at this age range. Therefore, as a coach I will never assume that just because one of the girls (ages 9-11) outperforms her entire class during a drill that it means I should expect the rest of the girls to be able to perform at the same level.

REASON 1 – Physical

The effect of testosterone on human sexual differentiation is an important factor, albeit not the *only* factor in causing boys to have an advantage over girls in sports. "Sexual dimorphism" (male versus female body design differences) arises from the interaction of testosterone and male genetics encoded by the SRY gene (usually found on the "Y" chromosome). The presence of testosterone in the womb triggers a male baby to begin its journey down the pathway to male morphology. There will be thousands of ways (from the cellular level to the overall anatomy level) in which a male baby diverges in form and physiology from a female baby. Height and weight charts at birth are sex specific, of course.[iv] Key differences in brain circuitry and musculoskeletal features develop before birth and will play a role in providing the male child with advantages related to sport performance. These involve the stitching together of subnetworks in the brain that provide a male child with better movement control, coordination, visual and special awareness, and internal proprioception.[v]

The article cited here mentions that there are differences even in the relative bone lengths of the fingers at birth, with boys having a longer 4th digit (ring finger) relative to the 2nd digit (index finger) and girls having a longer index finger (a larger "D2:D4 ratio"). This seemingly insignificant observation hints at sex-based differentiation in skeleton and joints. As a coach I witness with regularity how little boys have so much more strength in their upper body (upper torso, arms, and shoulders) compared to little girls. This manifests most noticeably when children try to climb or do pull-ups. Indeed, when I look at the data charts included in the *President's Council on Physical Fitness and Sports* (1985)[vi], I see that the sex difference is stark when it comes to such upper-body performance measures as pull-ups and flexed arm hang. Here is a summary of those data:

Average number of pull-ups at ages 6, 7 and 8:

Boys = 1.3, 1.8, 2.3

Girls = 0.7, 0.8, 1.0

Average time (seconds) a child can maintain the flexed arm hang at ages 6, 7 and 8:

Boys = 7.9, 10.6, 12.3

Girls = 7.1, 9.3, 9.7

The task of gripping a bar and pulling up one's own body weight involves a kind of "leveraging" of forces at the shoulder, upper torso, arms, and hands. In my educated opinion, the sex-based differences in this physical test strongly suggest that the bones and muscles of boys develop differently in structure. The shape of the shoulder joint, the angles of pull, the muscular strength, and durability of that entire set of bony and muscular levers, enables the boys to do so much more.

But, of course, there are differences in other measures, too. Data from the same *President's Council* tests include the following items:

- Mile Run (seconds)
- Long Jump (inches)
- 50 Yard Dash (seconds)
- Shuttle Run (seconds)
- 2 Mile Walk (seconds)
- Sit & Reach (inches)
- Sit-ups (number)

Here are the comparisons by age (highlighted scores are the ones where girls are equal or better):

At AGE 6

	BOYS	**GIRLS**
Mile Run	788.57	829.21
Long Jump	44.59	40.60
50 Yard Dash	10.22	10.68
Shuttle Run	13.47	13.88
2 Mile Walk	2038.02	2114.23
Sit & Reach	.64	2.43
Sit-ups	22.56	22.90

At AGE 7

	BOYS	**GIRLS**
Mile Run	726.96	789.73
Long Jump	47.36	43.30
50 Yard Dash	9.82	10.19
Shuttle Run	12.96	13.52
2 Mile Walk	2031.31	2146.35
Sit & Reach	.69	2.23
Sit-ups	27.16	25.37

At AGE 8

	BOYS	**GIRLS**
Mile Run	684.77	763.25
Long Jump	51.83	47.42
50 Yard Dash	9.27	9.71
Shuttle Run	12.39	13.15
2 Mile Walk	1969.93	2078.52
Sit & Reach	.18	2.06
Sit-ups	30.48	28.66

In summary, this testing protocol indicates that boys run faster, have greater endurance, are more agile, jump farther and have greater upper body strength than girls, whereas girls are more flexible (indicated here in the sit and reach test).

This sub-set of results from top finishers at the 2022 AAU National Championship Jr Olympics shows a similar outcome for 8-year-olds[vii]:

	BOYS	**GIRLS**
100m Dash (sec)	13.87	14.41
200m Dash (sec)	28.56	29.64
1500m Run	5:07.14	5:18.44
Long Jump (m)	4.09	3.86
Shot Put	31 ft 1.00 in	23 ft 4.75 in

This chart (above) provides additional evidence that is prototypical. Once again, boys are faster and throw and jump farther than girls. Measurements of lung function in small children - with boys having a higher lung volume[viii], more air passages and other enhanced capacities throughout the oxygen transport system[ix] - explains why they also do better in endurance tests and the 1500m run as reflected in the charts.

I leave it up to other experts like Dr. Gregory Brown and Dr. Emma Hilton, whose reports I have reviewed in preparing my opinion, to provide more such data. The point I wish to make here is that consistently across all data bases and amongst the the hundreds of children I have worked with as a coach, boys are better than girls in all fitness parameters except in flexibility and, possibly, balance.

In the realm of physical education and sports we refer to human movement capacities as "biomotor abilities." Some coaches say there are only five, but I recognize ten biomotor abilities (with the main physical factors that influence them in brackets):

- Strength (nervous system, muscles, bone structure & joints)
- Speed (nervous system, muscles, bone structure & joints)
- Stamina (cardiovascular system – heart, lungs, blood & cellular substructures)
- Power (nervous system, bone structure, muscles & joint durability)
- Speed-Endurance (cardiovascular system, bone structure, muscles, nervous system & cellular substructures)
- Muscular-Endurance (cardiovascular system, bone structure, muscles, nervous system & cellular substructures)
- Coordination (proprioception, nervous system, muscles & joints)
- Agility (proprioception, nervous system, muscles & joints)
- Balance (proprioception, location of center of gravity, nervous system & muscles)
- Flexibility (softness of joints; extensibility of muscles and ligaments)

And possibly an 11th one that only top coaches talk about (& professionals like NFL quarterback Tom Brady)[x]:

- Elasticity or Pliability (the ability of the entire body or parts of the body to "whip" – to bend and snap like an elastic band)

Due to the underlying structural differences in the nervous system, musculo-skeletal system, and cardio-vascular system, boys have the advantage in nine out of the eleven biomotor abilities.

Girls do excel in sports where flexibility is a dominant feature. For example, boys typically don't compete in rhythmic gymnastics. It requires body contortions that most males are simply unable to achieve. On the other hand, having hyper-flexible bodies accompanied by lower muscular strength renders girls are highly prone to impact injury in contact sports.

Since most sports involve a combination of biomotor abilities, the male performance advantage will be amplified. In a sport like volleyball, soccer, and basketball where strength, speed, power, endurance, agility, and coordination all come into play, the performance difference compared to the girls will be more obvious than what might be observed in a singular biomotor skill test.

This concept of "additive advantage" is the reason why changing one variable in a boy (say, testosterone level) will not work to fully diminish his performance advantage over his female counterparts. While hormone therapy might diminish a percentage of his original strength and, possibly, endurance, it will not adequately diminish other factors that add up to giving him an overwhelming advantage. For the sake of argument, if boys are better than girls because they are adding up a set of advantages "A + B + C + D + E + F," they will continue to have an advantage even if factor "D" is removed. The male advantage will then be of the set "A + B + C + E + F." It will *still be* insurmountable for the girls.

In summary, as a coach with extensive education in kinesiology – looking at human form and function - I can confirm without hesitation that prepubescent girls as a class will never be able to overcome the performance edge enjoyed by their male cohorts. While not as overwhelming as the differences encountered post-puberty, the sport performance differences enjoyed by pre-pubescent male children are significant and easily recognized by those of us involved: teachers, coaches, parents, and the children. The important point to be made here is that boys will dominate girls in competition because of prepubescent physical differences.

REASON 2 - Psychosocial

As a coach for almost 30 years observing boys and girls in sports competition, I have regularly observed the psychosocial risks of forcing girls to compete against boys. Most little girls simply do not wish to compete against the boys. Girls recognize the categorical difference in biological sex and, as a coach, I have seen quite often that little girls become intimidated when they are compelled to test themselves relative to boys. On a soccer field, a little girl will often stand back and let the boy take the ball. In games like dodgeball girls will often shy away from the aggressive play of boys. Conversely, when little girls compete with each other their confidence grows and they become far more engaged in the match.

This is the same phenomenon witnessed in girls-only schools. A disadvantage with having to compete with boys is described thus: "In coeducational classrooms, boys tend to monopolise discussion, and take more domineering roles in group work and in practical exercise." [xi] And: "…teachers [and coaches] tend to ignore the strong correlation between high motivation and high anxiety in many high-achieving girls. In girls-only environments, girls' needs and preferences come to the fore."

Based on my observations and interactions with children and families over the course of my 30 years of coaching, I have repeatedly seen that the moment a boy is mixed in with the girls in a highly competitive environment, much of the focus turns to him and his needs at the expense of the girls, who tend to quietly withdraw their assertiveness. Recently, a father told me that his nine-year-old daughter's soccer team had to play against another team that had a male child who "identifies as a girl." He said that the girls on his daughter's team became less energized than usual and did not even try to take the ball away from the boy. Their team ended up losing by many points and the girls left the field asking why they should even be playing. This is the opposite of female empowerment.

Female empowerment takes another huge hit when male children are allowed to share a locker room with the girls. One needs only to hear the testimony of swimmer Riley Gaines to understand the devastation and humiliation involved in dealing with compelled sharing of an intimate space.[xii] It leads to tears and long-lasting psychological distress.

The essence of positive empowerment is what happened when female-only sports exploded in popularity after the passage of Title IX. The numbers don't lie. While there is no data for primary schools, we can see what happened with older female students, as summarized in this chart:[xiii]

TIME	**MALE** participation in high school sports (number of boys)	**FEMALE** participation in high school sports (number of girls)
Before Title IX [School year 1971-1972]	3,666,917 (93%)	294,015 (7%)
After Title IX [School year 2018-2019]	4,534,758 (57%)	3,402,733 (43%)

These data show a 1,057% increase in female participation in school sports over a 45-year period. A similar increase is reflected in the NCAA data and the point is that never in the annals of world history has there been such a drastic change (improvement!) in the enthusiastic engagement and physical play of female persons.

The impact upon America has been unprecedented. Twenty years after the passage of Title IX (in the 1990s) along came the phenomenon of the "soccer mom" – mothers across America who piled their kids into the minivan determined to get their children into sports. A generation of both boys and girls now owe it to those moms for engaging them in sports and other physically active past times. Based on my observations, this volunteerism has had a positive impact on many children and on the sports associations.

One significant impact of granting girls the opportunity to engage in fair competition and to experience achievement has been on the American economy and the business environment. In clear contrast to the pre-1980s, there are now thousands of women across the USA who start their own businesses and lead companies.

What does this have to do with sports? Consider these facts revealed in an article by Forbes[xiv] magazine reporting on a study of working women undertaken by Ernst & Young:

"The study found that 90% of the women surveyed had played sports either at primary and secondary school, or during university or other tertiary education, with this proportion rising to 96% among C-suite women."

Almost all top female CEOs have had a sports background.

There can be no doubt that access to sport engendered by TitleIX has promoted the kind of self-confidence in America's little girls that has inspired them to grow into adult women pursuing high achievement. The benefit to society has been priceless.

CONCLUSION:

In conclusion, I must say that I am deeply concerned about the future of sports for young girls. We often hear the phrase, "Trans rights are human rights." This is true, but by the same token, "Female rights are human rights." Everyone has rights. But for an activity to be considered a "sport," the fundamental ingredient must be "fairness."

In 2021 when the UK Sport Council's Equality Group (SCEG) released its thorough review of transgender inclusion, it arrived at the following conclusion:

"As a result of what the review found, the guidance concludes that the inclusion of transgender people into female sport cannot be balanced regarding transgender inclusion, fairness and safety in gender-affected sport where there is meaningful competition."[xv]

According to the SCEG report, authorities in sex-affected sports must make a choice: prioritize transgender inclusion or prioritize fairness and safety for the female athlete.

I disagree in one way. I believe that we already have full inclusion in sports. Every human person has a biological sex, even if one wishes to self-identify or express as something different. Therefore, there can be a place for everyone within our sex-based eligibility systems.

Nobody benefits in the long run by mixing sports categories. It is my view that the Save Women's Sports Act preserves fairness in sports for female participants of all identities on the basis of sex, as intended by Title IX.

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

Dated: June 28, 2023 Signed: */s/ Dr. Linda Blade, Ph.D*

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[i] https://vault.si.com/vault/1997/08/25/teach-coaching-see-the-world-traveling-to-third-world-countries-to-train-coaches-is-linda-blades-idea-of-a-perfect-summer-vacation

[ii] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.northumberlandsportscouncil.ca/wp-content/uploads/2018/08/Run-Jump-Throw-Resource-.pdf

[iii] https://minilegends.ca/

[iv] https://www.cdc.gov/growthcharts/clinical_charts.htm#Set1

[v] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9331831/pdf/ijerph-19-09103.pdf (page. 3)

[vi] https://eric.ed.gov/?id=ED291714 (Appendix A, pages 56-57)

[vii] http://image2.aausports.org/sports/athletics/results/2022/jogames/jogamescompleteresults.htm

[viii] https://journals.physiology.org/doi/abs/10.1152/jappl.1962.17.4.601

[ix] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5980468/pdf/EDU-0003-2018.pdf

[x] https://www.youtube.com/watch?v=-SSP_qAUtYI

[xi] https://www.gdst.net/publications/why-and-how-girls-thrive-in-girls-only-schools/

[xii] https://www.dailysignal.com/2023/06/21/riley-gaines-describes-sharing-locker-room-lia-thomas/

[xiii] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.nfhs.org/media/1020205/2017-18_hs_participation_survey.pdf

[xiv] https://www.forbes.com/sites/alanaglass/2013/06/24/ernst-young-studies-the-connection-between-female-executives-and-sports/?sh=7edab51333a2

[xv] https://equalityinsport.org/docs/300921/Guidance%20for%20Transgender%20Inclusion%20in%20Domestic%20Sport%202021.pdf (p. 15)

EXHIBIT 6

WILENCHIK & BARTNESS
A PROFESSIONAL CORPORATION

A Policy Interpretation: Title IX and Intercollegiate Athletics

[OCR-00005]

Federal Register, Vol. 44, No. 239 - Tuesday, Dec. 11, 1979

Intercollegiate athletics policy interpretation; provides more specific factors to be reviewed by OCR under program factors listed at 34 C.F.R. Section 106.41 of the Title IX regulation; explains OCR's approach to determining compliance in intercollegiate athletics; adds two program factors, recruitment and support services, to be reviewed; clarifies requirement for athletic scholarships - 34 C.F.R. Section 106.37(c). The document contains dated references, and footnote 6 is out of date; however, the policy is still current.

Federal Register / Vol. 44, No. 239 / Tuesday, December 11, 1979 / Rules and Regulations

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Office for Civil Rights

Office of the Secretary

45 CFR Part 86

Title IX of the Education Amendments of 1972; a Policy Interpretation; Title IX and Intercollegiate Athletics

AGENCY: Office for Civil Rights, Office of the Secretary, HEW.

ACTION: Policy interpretation.

SUMMARY: The following Policy Interpretation represents the Department of Health, Education, and Welfare's interpretation of the intercollegiate athletic provisions of Title IX of the Education Amendments of 1972 and its implementing regulation. Title IX prohibits educational programs and institutions funded or otherwise supported by the Department from discriminating on the basis of sex. The Department published a proposed Policy Interpretation for public comment on December 11, 1978. Over 700 comments reflecting a broad range of opinion were received. In addition, HEW staff visited eight universities during June and July, 1979, to see how the proposed policy and other suggested alternatives would apply in actual practice at individual campuses. The final Policy Interpretation reflects the many comments HEW received and the results of the individual campus visits

EFFECTIVE DATE: December 11, 1979

FOR FURTHER INFORMATION CONTACT: Colleen O'Connor, 330 Independence Avenue, Washington, D.C. (202) 245-6671

SUPPLEMENTARY INFORMATION:

1. Legal Background

A. The Statute

Section 901(a) of Title IX of the Education Amendments of 1972 provides:

- No person in the United States shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity receiving Federal financial assistance.

Section 844 of the Education Amendments of 1974 further provides:

- The Secretary of [of HEW] shall prepare and publish * * * proposed regulations implementing the provisions of Title IX of the Education Amendments of 1972 relating to the prohibition of sex discrimination in federally assisted education programs which shall include with respect to intercollegiate athletic activities reasonable provisions considering the nature of particular sports.

Congress passed Section 844 after the Conference Committee deleted a Senate floor amendment that would have exempted revenue-producing athletics from the jurisdiction of Title IX.

B. The Regulation

The regulation implementing Title IX is set forth, in pertinent part, in the Policy Interpretation below. It was signed by President Ford on May 27, 1975, and submitted to the Congress for review pursuant to Section 431(d)(1) of the General Education Provisions Act (GEPA).

During this review, the House Subcommittee on Postsecondary Education held hearings on a resolution disapproving the regulation. The Congress did not disapprove the regulation within the 45 days allowed under GEPA, and it therefore became effective on July 21, 1975.

Subsequent hearings were held in the Senate Subcommittee on Education on a bill to exclude revenues produced by sports to the extent they are used to pay the costs of those sports. The Committee, however, took no action on this bill.

The regulation established a three year transition period to give institutions time to comply with its equal athletic opportunity requirements. That transition period expired on July 21, 1978.

II. Purpose of Policy Interpretation

By the end of July 1978, the Department had received nearly 100 complaints alleging discrimination in athletics against more than 50 institutions of higher education. In attempting to investigate these complaints, and to answer questions from the university community, the Department determined that it should provide further guidance on what constitutes compliance with the law. Accordingly, this Policy Interpretation explains the regulation so as to provide a framework within which the complaints can be resolved, and to provide institutions of higher education with additional guidance on the requirements for compliance with Title IX in intercollegiate athletic programs.

III. Scope of Application

This Policy Interpretation is designed specifically for intercollegiate athletics. However, its general principles will often apply to club, intramural, and interscholastic athletic programs, which are also covered by regulation.[1] Accordingly, the Policy Interpretation may be used for guidance by the administrators of such programs when appropriate.

This policy interpretation applies to any public or private institution, person or other entity that operates an educational program or activity which receives or benefits from financial assistance authorized or extended under a law administered by the Department. This includes educational institutions whose students participate in HEW funded or guaranteed student loan or assistance programs. For further information see definition of "recipient" in Section 86.2 of the Title IX regulation.

IV. Summary of Final Policy Interpretation

The final Policy Interpretation clarifies the meaning of "equal opportunity" in intercollegiate athletics. It explains the factors and standards set out in the law and regulation which the Department will consider in determining whether an institution's intercollegiate athletics program complies with the law and regulations. It also provides guidance to assist institutions in determining whether any disparities which may exist between men's and women's programs are justifiable and nondiscriminatory. The Policy Interpretation is divided into three sections:

- *Compliance in Financial Assistance (Scholarships) Based on Athletic Ability:* Pursuant to the regulation, the governing principle in this area is that all such assistance should be available on a substantially proportional basis to the number of male and female participants in the institution's athletic program.
- *Compliance in Other Program Areas (Equipment and supplies; games and practice times; travel and per diem, coaching and academic tutoring; assignment and compensation of coaches and tutors; locker rooms, and practice and competitive facilities; medical and training facilities; housing and dining facilities; publicity; recruitment; and support services):* Pursuant to the regulation, the governing principle is that male and female athletes should receive equivalent treatment, benefits, and opportunities.
- *Compliance in Meeting the Interests and Abilities of Male and Female Students:* Pursuant to the regulation, the governing principle in this area is that the athletic interests and abilities of male and female students must be equally effectively accommodated.

V. Major Changes to Proposed Policy Interpretation

The final Policy Interpretation has been revised from the one published in proposed form on December 11, 1978. The proposed Policy Interpretation was based on a two-part approach. Part I addressed equal opportunity for participants in athletic programs. It required the elimination of discrimination in financial support and other benefits and opportunities in an institution's existing athletic program. Institutions could establish a presumption of compliance if they could demonstrate that:

- "Average per capita" expenditures for male and female athletes were substantially equal in the area of "readily financially measurable" benefits and opportunities or, if not, that any disparities were the result of nondiscriminatory factors, and
- Benefits and opportunities for male and female athletes, in areas which are not financially measurable, "were comparable."

Part II of the proposed Policy Interpretation addressed an institution's obligation to accommodate effectively the athletic interests and abilities of women as well as men on a continuing basis. It required an institution either:

- To follow a policy of development of its women's athletic program to provide the participation and competition opportunities needed to accommodate the growing interests and abilities of women, or
- To demonstrate that it was effectively (and equally) accommodating the athletic interests and abilities of students, particularly as the interests and abilities of women students developed.

While the basic considerations of equal opportunity remain, the final Policy Interpretation sets forth the factors that will be examined to determine an institution's actual, as opposed to presumed, compliance with Title IX in the area of intercollegiate athletics.

The final Policy Interpretation does not contain a separate section on institutions' future responsibilities. However, institutions remain obligated by the Title IX regulation to accommodate effectively the interests and abilities of male and female students with regard to the selection of sports and levels of competition available. In most cases, this will entail development of athletic programs that substantially expand opportunities for women to participate and compete at all levels.

The major reasons for the change in approach are as follows:

(1) Institutions and representatives of athletic program participants expressed a need for more definitive guidance on what constituted compliance than the discussion of a presumption of compliance provided. Consequently the final Policy Interpretation explains the meaning of "equal athletic opportunity" in such a way as to facilitate an assessment of compliance.

(2) Many comments reflected a serious misunderstanding of the presumption of compliance. Most institutions based objections to the proposed Policy Interpretation in part on the assumption that failure to provide compelling justifications for disparities in per capita expenditures would have automatically resulted in a finding of noncompliance. In fact, such a failure would only have deprived an institution of the benefit of the presumption that it was in compliance with the law. The Department would still have had the burden of demonstrating that the institution was actually engaged in unlawful discrimination. Since the purpose of issuing a policy interpretation was to clarify the regulation, the Department has determined that the approach of stating actual compliance factors would be more useful to all concerned.

(3) The Department has concluded that purely financial measures such as the per capita test do not in themselves offer conclusive documentation of discrimination, except where the benefit or opportunity under review, like a scholarship, is itself financial in nature. Consequently, in the final Policy Interpretation, the Department has detailed the factors to be considered in assessing actual compliance. While per capita breakdowns and other devices to examine expenditure patterns will be used as tools of analysis in the Department's investigative process, it is achievement of "equal opportunity" for which recipients are responsible and to which the final Policy Interpretation is addressed.

A description of the comments received, and other information obtained through the comment/consultation process, with a description of Departmental action in response to the major points raised, is set forth at Appendix "B" to this document.

VI. Historic Patterns of Intercollegiate Athletics Program Development and Operations

In its proposed Policy Interpretation of December 11, 1978, the Department published a summary of historic patterns affecting the relative status of men's and women's athletic programs. The Department has modified that summary to reflect additional information obtained during the comment and consultation process. The summary is set forth at Appendix A to this document.

VII. The Policy Interpretation

This Policy Interpretation clarifies the obligations which recipients of Federal aid have under Title IX to provide equal opportunities in athletic programs. In particular, this Policy Interpretation provides a means to assess an institution's compliance with the equal opportunity requirements of the regulation which are set forth at 45 CFR 88.37(c) and 88.41(c).

A. Athletic Financial Assistance (Scholarships)

1. *The Regulation*—Section 86.37(c) of the regulation provides:

> [Institutions] must provide reasonable opportunities for such award [of financial assistance] for member of each sex in proportion to the number of students of each sex participating in * * * inter-collegiate athletics.[2]

2. *The Policy*—The Department will examine compliance with this provision of the regulation primarily by means of a financial comparison to determine whether proportionately equal amounts of financial assistance (scholarship aid) are available to men's and women's athletic programs. The Department will measure compliance with this standard by dividing the amounts of aid available for the members of each sex by the numbers of male or female participants in the athletic program and comparing the results. Institutions may be found in compliance if this comparison results in substantially equal amounts or if a resulting disparity can be explained by adjustments to take into account legitimate, nondiscriminatory factors. Two such factors are:

a. At public institutions, the higher costs of tuition for students from out-of-state may in some years be unevenly distributed between men's and women's programs. These differences will be considered nondiscriminatory if they are not the result of policies or practices which disproportionately limit the availability of out-of-state scholarships to either men or women.

b. An institution may make reasonable professional decisions concerning the awards most appropriate for program development. For example, team development initially may require spreading scholarships over as much as a full generation (four years) of student athletes. This may result in the award of fewer scholarships in the first few years than would be necessary to create proportionality between male and female athletes.

3. *Application of the Policy*—a. This section does not require a proportionate number of scholarships for men and women or individual scholarships of equal dollar value. It does mean that the total amount of scholarship aid made available to men and women must be substantially proportionate to their participation rates.

b. When financial assistance is provided in forms other than grants, the distribution of non-grant assistance will also be compared to determine whether equivalent benefits are proportionately available to male and female athletes. A disproportionate amount of work-related aid or loans in the assistance made available to the members of one sex, for example, could constitute a violation of Title IX.

Definition—For purposes of examining compliance with this Section, the participants will be defined as those athletes:

a. Who are receiving the institutionally-sponsored support normally provided to athletes competing at the institution involved, e.g., coaching, equipment, medical and training room services, on a regular basis during a sport's season; and

b. Who are participating in organized practice sessions and other team meetings and activities on a regular basis during a sport's season: and

c. Who are listed on the eligibility or squad lists maintained for each sport, or

d. Who, because of injury, cannot meet a, b, or c above but continue to receive financial aid on the basis of athletic ability.

B. Equivalence in Other Athletic Benefits and Opportunities

1. *The Regulation*—The Regulation requires that recipients that operate or sponsor interscholastic, intercollegiate, club or intramural athletics. "provide equal athletic opportunities for members of both sexes." In determining whether an institution is providing equal opportunity in intercollegiate athletics the regulation requires the Department to consider, among others, the following factors:

(1) [3]

(2) Provision and maintenance of equipment and supplies;

(3) Scheduling of games and practice times;

(4) Travel and per diem expenses;

(5) Opportunity to receive coaching and academic tutoring;

(6) Assignment and compensation of coaches and tutors;

(7) Provision of locker rooms, practice and competitive facilities;

(8) Provision of medical and training services and facilities;

(9) Provision of housing and dining services and facilities; and

(10) Publicity

Section 86.41(c) also permits the Director of the Office for Civil Rights to consider other factors in the determination of equal opportunity. Accordingly, this Section also addresses recruitment of student athletes and provision of support services.
This list is not exhaustive. Under the regulation, it may be expanded as necessary at the discretion of the Director of the Office for Civil Rights.[4]

2. *The Policy*—The Department will assess compliance with both the recruitment and the general athletic program requirements of the regulation by comparing the availability, quality and kinds of benefits, opportunities, and treatment afforded members of both sexes. Institutions will be in compliance if the compared program components are equivalent, that is, equal or equal in effect. Under this standard, identical benefits, opportunities, or treatment are not required, provided the overall effects of any differences is negligible.

If comparisons of program components reveal that treatment, benefits, or opportunities are not equivalent in kind, quality or availability, a finding of compliance may still be justified if the differences are the result of nondiscriminatory factors. Some of the factors that may justify these differences are as follows:

a. Some aspects of athletic programs may not be equivalent for men and women because of unique aspects of particular sports or athletic activities. This type of distinction was called for by the "Javits' Amendment" [5] to Title IX which instructed HEW to make "reasonable (regulatory) provisions considering the nature of particular sports" in intercollegiate athletics.

Generally, these differences will be the result of factors that are inherent to the basic operation of specific sports. Such factors may include rules of play, nature/replacement of equipment, rates of injury resulting from participation, nature of facilities required for competition, and the maintenance/ upkeep requirements of those facilities. For the most part, differences involving such factors will occur in programs offering football, and consequently these differences will favor men. If sport-specific needs are met equivalently in both men's and women's programs, however, differences in particular program components will be found to be justifiable.

b. Some aspects of athletic programs may not be equivalent for men and women because of legitimately sex-neutral factors related to special circumstances of a temporary nature. For example, large disparities in recruitment activity for any particular year may be the result of annual fluctuations in team needs for first-year athletes. Such differences are justifiable to the extent that they do not reduce overall equality of opportunity.

c. The activities directly associated with the operation of a competitive event in a single-sex sport may, under some circumstances, create unique demands or imbalances in particular program components. Provided any special demands associated with the activities of sports involving participants of the other sex are met to an equivalent degree, the resulting differences may be found nondiscriminatory. At many schools, for example, certain sports—notably football and men's basketball—traditionally draw large crowds. Since the costs of managing an athletic event increase with crowd size, the overall support made available for event management to men's and women's programs may differ in degree and kind. These differences would not violate Title IX if the recipient does not limit the potential for women's athletic events to rise in spectator appeal and if the levels of event management support available to both programs are based on sex-neutral criteria (e.g., facilities used, projected attendance, and staffing needs).

d. Some aspects of athletic programs may not be equivalent for men and women because institutions are undertaking voluntary affirmative actions to overcome effects of historical conditions that have limited participation in athletics by the members of one sex. This is authorized at § 86.3(b) of the regulation.

3. *Application of the Policy—General Athletic Program Components—*

a. *Equipment and Supplies (§ 86.41(c)(2))*. Equipment and supplies include but are not limited to uniforms, other apparel, sport-specific equipment and supplies, general equipment and supplies, instructional devices, and conditioning and weight training equipment.

Compliance will be assessed by examining, among other factors, the equivalence for men and women of:

(1) The quality of equipment and supplies;

(2) The amount of equipment and supplies;

(3) The suitability of equipment and supplies;

(4) The maintenance and replacement of the equipment and supplies; and

(5) The availability of equipment and supplies.

b. *Scheduling of Games and Practice Times (§ 86.41(c)(3)).* Compliance will be assessed by examining, among other factors, the equivalence for men and women of:

(1) The number of competitive events per sport;

(2) The number and length of practice opportunities;

(3) The time of day competitive events are scheduled;

(4) The time of day practice opportunities are scheduled; and

(5) The opportunities to engage in available pre-season and post-season competition.

c. *Travel and Per Diem Allowances (§ 86.41(c)(4)).* Compliance will be assessed by examining, among other factors, the equivalence for men and women of:

(1) Modes of transportation;

(2) Housing furnished during travel;

(3) Length of stay before and after competitive events;

(4) Per diem allowances; and

(5) Dining arrangements.

d. *Opportunity to Receive Coaching and Academic Tutoring (§ 86.41(c)(5)).*

(1) Coaching—Compliance will be assessed by examining, among other factors:

(a) Relative availability of full-time coaches;

(b) Relative availability of part-time and assistant coaches; and

(c) Relative availability of graduate assistants.

(2) Academic tutoring—Compliance will be assessed by examining, among other factors, the equivalence for men and women of:

(a) The availability of tutoring; and

(b) Procedures and criteria for obtaining tutorial assistance.

e. *Assignment and Compensation of Coaches and Tutors (§ 86.41(c)(6)).*[6] In general, a violation of Section 86.41(c)(6) will be found only where compensation or assignment policies or practices deny male and female athletes coaching of equivalent quality, nature, or availability.

Nondiscriminatory factors can affect the compensation of coaches. In determining whether differences are caused by permissible factors, the range and nature of duties, the experience of individual coaches, the number of participants for particular sports, the number of assistant coaches supervised, and the level of competition will be considered.

Where these or similar factors represent valid differences in skill, effort, responsibility or working conditions they may, in specific circumstances, justify differences in compensation. Similarly, there may be unique situations in which a particular person may possess such an outstanding record of achievement as to justify an abnormally high salary.

(1) Assignment of Coaches—Compliance will be assessed by examining, among other factors, the equivalence for men's and women's coaches of:

(a) Training, experience, and other professional qualifications;

(b) Professional standing.

(2) Assignment of Tutors—Compliance will be assessed by examining, among other factors, the equivalence for men's and women's tutors of:

(a) Tutor qualifications;

(b) Training, experience, and other qualifications.

(3) Compensation of Coaches—Compliance will be assessed by examining, among other factors, the equivalence for men's and women's coaches of:

(a) Rate of compensation (per sport, per season);

(b) Duration of contracts;

(c) Conditions relating to contract renewal;

(d) Experience;

(e) Nature of coaching duties performed;

(f) Working conditions; and

(g) Other terms and conditions of employment.

(4) Compensation of Tutors—Compliance will be assessed by examining, among other factors, the equivalence for men's and women's tutors of:

(a) Hourly rate of payment by nature subjects tutored;

(b) Pupil loads per tutoring season;

(c) Tutor qualifications;

(d) Experience;

(e) Other terms and conditions of employment.

f. *Provision of Locker Rooms, Practice and Competitive Facilities (§ 86.41(c)(7))*. Compliance will be assessed by examining, among other factors, the equivalence for men and women of:

(1) Quality and availability of the facilities provided for practice and competitive events;

(2) Exclusivity of use of facilities provided for practice and competitive events;

(3) Availability of locker rooms;

(4) Quality of locker rooms;

(5) Maintenance of practice and competitive facilities; and

(6) Preparation of facilities for practice and competitive events.

g. *Provision of Medical and Training Facilities and Services (§ 86.41(c)(8)).* Compliance will be assessed by examining, among other factors, the equivalence for men and women of:

(1) Availability of medical personnel and assistance;

(2) Health, accident and injury insurance coverage;

(3) Availability and quality of weight and training facilities;

(4) Availability and quality of conditioning facilities; and

(5) Availability and qualifications of athletic trainers.

h. *Provision of Housing and Dining Facilities and Services (§ 86.41(c)(9)).* Compliance will be assessed by examining, among other factors, the equivalence for men and women of:

(1) Housing provided;

(2) Special services as part of housing arrangements (e.g., laundry facilities, parking space, maid service).

i. *Publicity (§ 86.41(c)(10)).* Compliance will be assessed by examining, among other factors, the equivalence for men and women of:

(1) Availability and quality of sports information personnel;

(2) Access to other publicity resources for men's and women's programs; and

(3) Quantity and quality of publications and other promotional devices featuring men's and women's programs.

4. *Application of the Policy—Other Factors (§ 86.41(c)).* a. *Recruitment of Student Athletes*.[7] The athletic recruitment practices of institutions often affect the overall provision of opportunity to male and female athletes. Accordingly, where equal athletic opportunities are not present for male and female students, compliance will be assessed by examining the recruitment practices of the athletic programs for both sexes to determine whether the provision of equal opportunity will require modification of those practices.

Such examinations will review the following factors:

(1) Whether coaches or other professional athletic personnel in the programs serving male and female athletes are provided with substantially equal opportunities to recruit;

(2) Whether the financial and other resources made available for recruitment in male and female athletic programs are equivalently adequate to meet the needs of each program; and

(3) Whether the differences in benefits, opportunities, and treatment afforded prospective student athletes of each sex have a disproportionately limiting effect upon the recruitment of students of either sex.

b. *Provision of Support Services.* The administrative and clerical support provided to an athletic program can affect the overall provision of opportunity to male and female athletes, particularly to the extent that the provided services enable coaches to perform better their coaching functions.

In the provision of support services, compliance will be assessed by examining, among other factors, the equivalence of:

(1) The amount of administrative assistance provided to men's and women's programs;

(2) The amount of secretarial and clerical assistance provided to men's and women's programs.

5. *Overall Determination of Compliance.* The Department will base its compliance determination under ' 86.41(c) of the regulation upon an examination of the following:

a. Whether the policies of an institution are discriminatory in language or effect; or

b. Whether disparities of a substantial and unjustified nature exist in the benefits, treatment, services, or opportunities afforded male and female athletes in the institution's program as a whole; or

c. Whether disparities in benefits, treatment, services, or opportunities in individual segments of the program are substantial enough in and of themselves to deny equality of athletic opportunity.

C. Effective Accommodation of Student Interests and Abilities.

1. *The Regulation.* The regulation requires institutions to accommodate effectively the interests and abilities of students to the extent necessary to provide equal opportunity in the selection of sports and levels of competition available to members of both sexes.

Specifically, the regulation, at § 86.41(c)(1), requires the Director to consider, when determining whether equal opportunities are available—

Whether the selection of sports and levels of competition effectively accommodate the interests and abilities of members of both sexes.

Section 86.41(c) also permits the Director of the Office for Civil Rights to consider other factors in the determination of equal opportunity. Accordingly, this section also addresses competitive opportunities in terms of the competitive team schedules available to athletes of both sexes.

2. *The Policy*. The Department will assess compliance with the interests and abilities section of the regulation by examining the following factors:

a. The determination of athletic interests and abilities of students;

b. The selection of sports offered; and

c. The levels of competition available including the opportunity for team competition.

3. *Application of the Policy—Determination of Athletic Interests and Abilities.*

Institutions may determine the athletic interests and abilities of students by nondiscriminatory methods of their choosing provided:

a. The processes take into account the nationally increasing levels of women's interests and abilities;

b. The methods of determining interest and ability do not disadvantage the members of an underrepresented sex;

c. The methods of determining ability take into account team performance records; and

d. The methods are responsive to the expressed interests of students capable of intercollegiate competition who are members of an underrepresented sex.

4. *Application of the Policy—Selection of Sports.*

In the selection of sports, the regulation does not require institutions to integrate their teams nor to provide exactly the same choice of sports to men and women. However, where an institution sponsors a team in a particular sport for members of one sex, it may be required either to permit the excluded sex to try out for the team or to sponsor a separate team for the previously excluded sex.

a. Contact Sports—Effective accommodation means that if an institution sponsors a team for members of one sex in a contact sport, it must do so for members of the other sex under the following circumstances:

(1) The opportunities for members of the excluded sex have historically been limited; and

(2) There is sufficient interest and ability among the members of the excluded sex to sustain a viable team and a reasonable expectation of intercollegiate competition for that team.

b. Non-Contact Sports—Effective accommodation means that if an institution sponsors a team for members of one sex in a non-contact sport, it must do so for members of the other sex under the following circumstances:

(1) The opportunities for members of the excluded sex have historically been limited;

(2) There is sufficient interest and ability among the members of the excluded sex to sustain a viable team and a reasonable expectation of intercollegiate competition for that team; and

(3) Members of the excluded sex do not possess sufficient skill to be selected for a single integrated team, or to compete actively on such a team if selected.

5. *Application of the Policy—Levels of Competition.*

In effectively accommodating the interests and abilities of male and female athletes, institutions must provide both the opportunity for individuals of each sex to participate in intercollegiate competition, and for athletes of each sex to have competitive team schedules which equally reflect their abilities.

a. Compliance will be assessed in any one of the following ways:

(1) Whether intercollegiate level participation opportunities for male and female students are provided in numbers substantially proportionate to their respective enrollments; or

(2) Where the members of one sex have been and are underrepresented among intercollegiate athletes, whether the institution can show a history and continuing practice of program expansion which is demonstrably responsive to the developing interest and abilities of the members of that sex; or

(3) Where the members of one sex are underrepresented among intercollegiate athletes, and the institution cannot show a continuing practice of program expansion such as that cited above, whether it can be demonstrated that the interests and abilities of the members of that sex have been fully and effectively accommodated by the present program.

b. Compliance with this provision of the regulation will also be assessed by examining the following:

(1) Whether the competitive schedules for men's and women's teams, on a program-wide basis, afford proportionally similar numbers of male and female athletes equivalently advanced competitive opportunities; or

(2) Whether the institution can demonstrate a history and continuing practice of upgrading the competitive opportunities available to the historically disadvantaged sex as warranted by developing abilities among the athletes of that sex.

c. Institutions are not required to upgrade teams to intercollegiate status or otherwise develop intercollegiate sports absent a reasonable expectation that intercollegiate competition in that sport will be available within the institution's normal competitive regions. Institutions may be required by the Title IX regulation to actively encourage the development of such competition, however, when overall athletic opportunities within that region have been historically limited for the members of one sex.

6. *Overall Determination of Compliance.*

The Department will base its compliance determination under § 86.41(c) of the regulation upon a determination of the following:

a. Whether the policies of an institution are discriminatory in language or effect; or

b. Whether disparities of a substantial and unjustified nature in the benefits, treatment, services, or opportunities afforded male and female athletes exist in the institution's program as a whole; or

c. Whether disparities in individual segments of the program with respect to benefits, treatment, services, or opportunities are substantial enough in and of themselves to deny equality of athletic opportunity.

VIII. The Enforcement Process

The process of Title IX enforcement is set forth in § 88.71 of the Title IX regulation, which incorporates by reference the enforcement procedures applicable to Title VI of the Civil Rights Act of 1964.[8] The enforcement process prescribed by the regulation is supplemented by an order of the Federal District Court, District of Columbia, which establishes time frames for each of the enforcement steps.[9]

According to the regulation, there are two ways in which enforcement is initiated:

- *Compliance Reviews*—Periodically the Department must select a number of recipients (in this case, colleges and universities which operate intercollegiate athletic programs) and conduct investigations to

determine whether recipients are complying with Title IX (45 CFR 80.7(a))
- *Complaints*—The Department must investigate all valid (written and timely) complaints alleging discrimination on the basis of sex in a recipient's programs. (45 CFR 80.7(b))

The Department must inform the recipient (and the complainant, if applicable) of the results of its investigation. If the investigation indicates that a recipient is in compliance, the Department states this, and the case is closed. If the investigation indicates noncompliance, the Department outlines the violations found.

The Department has 90 days to conduct an investigation and inform the recipient of its findings, and an additional 90 days to resolve violations by obtaining a voluntary compliance agreement from the recipient. This is done through negotiations between the Department and the recipient, the goal of which is agreement on steps the recipient will take to achieve compliance. Sometimes the violation is relatively minor and can be corrected immediately. At other times, however, the negotiations result in a plan that will correct the violations within a specified period of time. To be acceptable, a plan must describe the manner in which institutional resources will be used to correct the violation. It also must state acceptable time tables for reaching interim goals and full compliance. When agreement is reached, the Department notifies the institution that its plan is acceptable. The Department then is obligated to review periodically the implementation of the plan.

An institution that is in violation of Title IX may already be implementing a corrective plan. In this case, prior to informing the recipient about the results of its investigation, the Department will determine whether the plan is adequate. If the plan is not adequate to correct the violations (or to correct them within a reasonable period of time) the recipient will be found in noncompliance and voluntary negotiations will begin. However, if the institutional plan is acceptable, the Department will inform the institution that although the institution has violations, it is found to be in compliance because it is implementing a corrective plan. The Department, in this instance also, would monitor the progress of the institutional plan. If the institution subsequently does not completely implement its plan, it will be found in noncompliance.

When a recipient is found in noncompliance and voluntary compliance attempts are unsuccessful, the formal process leading to termination of Federal assistance will be begun. These procedures, which include the opportunity for a hearing before an administrative law judge, are set forth at 45 CFR 80.8–80.11 and 45 CFR Part 81.

IX. Authority

(Secs. 901, 902, Education Amendments of 1972, 86 Stat. 373, 374, 20 U.S.C. 1681, 1682; sec. 844, Education Amendments of 1974, Pub. L. 93-380, 88 Stat. 612; and 45 CFR Part 86)

Dated December 3, 1979.

Roma Stewart,

Director, Office for Civil Rights, Department of Health, Education, and Welfare.

Dated December 4, 1979.

Patricia Roberts Harris,

Secretary, Department of Health, Education, and Welfare.

Appendix A—Historic Patterns of Intercollegiate Athletics Program Development

1. Participation in intercollegiate sports has historically been emphasized for men but not women. Partially as a consequence of this, participation rates of women are far below those of men. During the 1977–78 academic year women students accounted for 48 percent of the national undergraduate enrollment (5,496,000 of 11,267,000 students).[1] Yet, only 30 percent of the intercollegiate athletes are women.[2]

The historic emphasis on men's intercollegiate athletic programs has also contributed to existing differences in the number of sports and scope of competition offered men and women. One source indicates that, on the average, colleges and universities are providing twice the number of sports for men as they are for women.[3]

2. Participation by women in sports is growing rapidly. During the period from 1971–1978, for example, the number of female participants in organized high school sports increased from 294,000 to 2,083,000—an increase of over 600 percent.[4] In contrast, between Fall 1971 and Fall 1977, the enrollment of females in high school decreased from approximately 7,600,000 to approximately 7,150,000 a decrease of over 5 percent.[5]

The growth in athletic participation by high school women has been reflected on the campuses of the nation's colleges and universities. During the period from 1971 to 1976 the enrollment of women in the nation's institutions of higher education rose 52 percent, from 3,400,000 to 5,201,000.[6] During this same period, the number of women participating in intramural sports increased 108 percent from 276,167 to 576,167. In club sports, the number of women participants increased from 16,386 to 25,541 or 55 percent. In intercollegiate sports, women's participation increased 102 percent from 31,852 to 64,375.[7] These developments reflect the growing interest of women in competitive athletics, as well as the efforts of colleges and universities to accommodate those interests.

3. The overall growth of women's intercollegiate programs has not been at the expense of men's programs. During the past decade of rapid growth in women's programs, the number of intercollegiate sports available for men has remained stable, and the number of male athletes has increased slightly. Funding for men's programs has increased from $1.2 to $2.2 million between 1970–1977 alone.[8]

4. On most campuses, the primary problem confronting women athletes is the absence of a fair and adequate level of resources, services, and benefits. For example, disproportionately more financial aid has been made available for male athletes than for female athletes. Presently, in institutions that are members of both the National Collegiate Athletic Association (NCAA) and the Association for Intercollegiate Athletics for Women (AIAW), the average annual scholarship budget is $39,000. Male athletes receive $32,000 or 78 percent of this amount, and female athletes receive $7,000 or 22 percent, although women are 30 percent of all the athletes eligible for scholarships.[9]

Likewise, substantial amounts have been provided for the recruitment of male athletes, but little funding has been made available for recruitment of female athletes.
Congressional testimony on Title IX and subsequent surveys indicates that discrepancies also exist in the opportunity to receive coaching and in other benefits and opportunities, such as the quality and amount of equipment, access to facilities and practice times, publicity, medical and training facilities, and housing and dining facilities.[10]

5. At several institutions, intercollegiate football is unique among sports. The size of the teams, the expense of the operation, and the revenue produced distinguish football from other sports, both men's and women's. Title IX requires that "an institution of higher education must comply with the prohibition against sex discrimination imposed by that title and its implementing regulations in the administration of any revenue producing intercollegiate athletic activity."[11] However, the unique size and cost of football programs have been taken into account in developing this Policy Interpretation.

Appendix B—Comments and Responses

The Office for Civil Rights (OCR) received over 700 comments and recommendations in response to the December 11, 1978 publication of the proposed Policy Interpretation. After the formal comment period, representatives of the Department met for additional discussions with many individuals and groups including college and university officials, athletic associations, athletic directors, women's rights organizations and other interested parties. HEW representatives also visited eight universities in order to assess the potential of the proposed Policy Interpretation and of suggested alternative approaches for effective enforcement of Title IX.

The Department carefully considered all information before preparing the final policy. Some changes in the structure and substance of the Policy Interpretation have been made as a result of concerns that were identified in the comment and consultation process.
Persons who responded to the request for public comment were asked to comment generally and also to respond specifically to eight questions that focused on different aspects of the proposed Policy Interpretation.

Question No. 1: Is the description of the current status and development of intercollegiate athletics for men and women accurate? What other factors should be considered?

Comment A: Some commentors noted that the description implied the presence of intent on the part of all universities to discriminate against women. Many of these same commentors noted an absence of concern in the proposed Policy Interpretation for those universities that have in good faith attempted to meet what they felt to be a vague compliance standard in the regulation.

Response: The description of the current status and development of intercollegiate athletics for men and women was designed to be a factual, historical overview. There was no intent to imply the universal presence of discrimination. The Department recognizes that there are many colleges and universities that have been and are making good faith efforts, in the midst of increasing financial pressures, to provide equal athletic opportunities to their male and female athletes.

Comment B: Commentors stated that the statistics used were outdated in some areas, incomplete in some areas, and inaccurate in some areas.

Response: Comment accepted. The statistics have been updated and corrected where necessary.

Question No. 2: Is the proposed two-stage approach to compliance practical? Should it be modified? Are there other approaches to be considered?

Comment: Some commentors stated that Part II of the proposed Policy Interpretation "Equally Accommodating the Interests and Abilities of Women" represented an extension of the July 1978, compliance deadline established in § 86.41(d) of the Title IX regulation.

Response: Part II of the proposed Policy Interpretation was not intended to extend the compliance deadline. The format of the two stage approach, however, seems to have encouraged that perception; therefore, the elements of both stages have been unified in this Policy Interpretation.

Question No. 3: Is the equal average per capita standard based on participation rates practical? Are there alternatives or modifications that should be considered?

Comment A: Some commentors stated it was unfair or illegal to find noncompliance solely on the basis of a financial test when more valid indicators of equality of opportunity exist.

Response: The equal average per capita standard was not a standard by which noncompliance could be found. It was offered as a standard of presumptive compliance. In order to prove noncompliance, HEW would have been required to show that the unexplained disparities in expenditures were discriminatory in effect. The standard, in part, was offered as a means of simplifying proof of compliance for universities. The widespread confusion concerning the significance of failure to satisfy the equal average per capita expenditure standard, however, is one of the reasons it was withdrawn.

Comment B: Many commentors stated that the equal average per capita standard penalizes those institutions that have increased participation opportunities for women and rewards institutions that have limited women's participation.

Response: Since equality of average per capita expenditures has been dropped as a standard of presumptive compliance, the question of its effect is no longer relevant. However, the Department agrees that universities that had increased participation opportunities for women and wished to take advantage of the presumptive compliance standard, would have had a bigger financial burden than universities that had done little to increase participation opportunities for women.

Question No. 4: Is there a basis for treating part of the expenses of a particular revenue producing sport differently because the sport produces income used by the university for non-athletic operating expenses on a non-discriminatory basis? If, so, how should such funds be identified and treated?

Comment: Commentors stated that this question was largely irrelevant because there were so few universities at which revenue from the athletic program was used in the university operating budget.

Response: Since equality of average per capita expenditures has been dropped as a standard of presumed compliance, a decision is no longer necessary on this issue.

Question No. 5: Is the grouping of financially measurable benefits into three categories practical? Are there alternatives that should be considered? Specifically, should recruiting expenses be considered together with all other financially measurable benefits?

Comment A: Most commentors stated that, if measured solely on a financial standard, recruiting should be grouped with the other financially measurable items. Some of these commentors held that at the current stage of development of women's intercollegiate athletics, the amount of money that would flow into the women's recruitment budget as a result of separate application of the equal average per capita standard to recruiting expenses, would make recruitment a disproportionately large percentage of the entire women's budget. Women's athletic directors, particularly, wanted the flexibility to have the money available for other uses, and they generally agreed on including recruitment expenses with the other financially measurable items.

Comment B: Some commentors stated that it was particularly inappropriate to base any measure of compliance in recruitment solely on financial expenditures. They stated that even if proportionate amounts of money were allocated to recruitment, major inequities could remain in the benefits to athletes. For instance, universities could maintain a policy of subsidizing visits to their campuses of prospective students of one sex but not the other. Commentors suggested that including an examination of differences in benefits to prospective athletes that result from recruiting methods would be appropriate.

Response: In the final Policy Interpretation, recruitment has been moved to the group of program areas to be examined under § 86.41(c) to determine whether overall equal athletic opportunity exists. The Department accepts the comment that a financial measure is not sufficient to determine whether equal opportunity is being provided. Therefore, in examining athletic recruitment, the Department will primarily review the opportunity to recruit, the resources provided for recruiting, and methods of recruiting.

Question No. 6: Are the factors used to justify differences in equal average per capita expenditures for financially measurable benefits and opportunities fair? Are there other factors that should be considered?

Comment: Most commentors indicated that the factors named in the proposed Policy Interpretation (the "scope of competition" and the "nature of the sport") as justifications for differences in equal average per capita expenditures were so vague and ambiguous as to be meaningless. Some stated that it would be impossible to define the phrase "scope of competition", given the greatly differing competitive structure of men's and women's programs. Other commentors were concerned that the "scope of competition" factor that may currently be designated as "nondiscriminatory" was, in reality, the result of many years of inequitable treatment of women's athletic programs.

Response: The Department agrees that it would have been difficult to define clearly and then to quantify the "scope of competition" factor. Since equal average per capita expenditures has been dropped as a standard of presumed compliance, such financial justifications are no longer necessary. Under the equivalency standard, however, the "nature of the sport" remains an important concept. As explained within the Policy Interpretation, the unique nature of a sport may account for perceived inequities in some program areas.

Question No 7: Is the comparability standard for benefits and opportunities that are not financially measurably fair and realistic? Should other factors controlling comparability be included? Should the comparability standard be revised? Is there a different standard which should be considered?

Comment: Many commentors stated that the comparability standard was fair and realistic. Some commentors were concerned, however, that the standard was vague and subjective and could lead to uneven enforcement.

Response: The concept of comparing the non-financially measurable benefits and opportunities provided to male and female athletes has been preserved and expanded in the final Policy Interpretation to include all areas of examination except scholarships and accommodation of the interests and abilities of both sexes. The standard is that equivalent benefits and opportunities must be provided. To avoid vagueness and subjectivity, further guidance is given about what elements will be considered in each program area to determine the equivalency of benefits and opportunities.

Question No. 8: Is the proposal for increasing the opportunity for women to participate in competitive athletics appropriate and effective? Are there other procedures that should be considered? Is there a more effective way to ensure that the interest and abilities of both men and women are equally accommodated?

Comment: Several commentors indicated that the proposal to allow a university to gain the status of presumed compliance by having policies and procedures to encourage the growth of women's athletics was appropriate and effective for future students, but ignored students presently enrolled. They indicated that nowhere in the proposed Policy Interpretation was concern shown that the current selection of sports and levels of competition effectively accommodate the interests and abilities of women as well as men.

Response: Comment accepted. The requirement that universities equally accommodate the interests and abilities of their male and female athletes (Part II of the proposed Policy Interpretation) has been directly addressed and is now a part of the unified final Policy Interpretation.

Additional Comments

The following comments were not responses to questions raised in the proposed Policy Interpretation. They represent additional concerns expressed by a large number of commentors.

(1) *Comment:* Football and other "revenue producing" sports should be totally exempted or should receive special treatment under Title IX.

Response: The April 18, 1978, opinion of the General Counsel, HEW, concludes that "an institution of higher education must comply with the prohibition against sex discrimination imposed by that title and its implementing regulation in the administration of any revenue producing activity". Therefore, football or other "revenue producing" sports cannot be exempted from coverage of Title IX.

In developing the proposed Policy Interpretation the Department concluded that although the fact of revenue production could not justify disparity in average per capita expenditure between men and women, there were characteristics common to most revenue producing sports that could result in legitimate nondiscriminatory differences in per capita expenditures. For instance, some "revenue producing" sports require expensive protective equipment and most require high expenditures for the management of events attended by large numbers of people. These characteristics and others described in the proposed Policy Interpretation were considered acceptable, nondiscriminatory reasons for differences in per capita average expenditures.

In the final Policy Interpretation, under the equivalent benefits and opportunities standard of compliance, some of these non-discriminatory factors are still relevant and applicable.

(2) *Comment:* Commentors stated that since the equal average per capita standard of presumed compliance was based on participation rates, the word should be explicitly defined.

Response: Although the final Policy Interpretation does not use the equal average per capita standard of presumed compliance, a clear understanding of the word "participant" is still necessary, particularly in the determination of compliance where scholarships are involved. The word "participant" is defined in the final Policy Interpretation.

(3) *Comment:* Many commentors were concerned that the proposed Policy Interpretation neglected the rights of individuals.

Response: The proposed Policy Interpretation was intended to further clarify what colleges and universities must do within their intercollegiate athletic programs to avoid discrimination against individuals on the basis of sex. The Interpretation, therefore, spoke to institutions in terms of their male and female athletes. It spoke specifically in terms of equal, average per capita expenditures and in terms of comparability of other opportunities and benefits for male and female participating athletes.

The Department believes that under this approach the rights of individuals were protected. If women athletes, as a class, are receiving opportunities and benefits equal to those of male athletes, individuals within the class should be protected thereby. Under the proposed Policy Interpretation, for example, if female athletes as a whole were receiving their proportional share of athletic financial assistance, a university would have been presumed in compliance with that section of the regulation. The Department does not want and does not have the authority to force universities to offer identical programs to men and women. Therefore, to allow flexibility within women's programs and within men's programs, the proposed Policy Interpretation stated that an institution would be presumed in compliance if the average per capita expenditures on athletic scholarships for men and women, were equal. This same flexibility (in scholarships and in other areas) remains in the final Policy Interpretation.

(4) *Comment:* Several commentors stated that the provision of a separate dormitory to athletes of only one sex, even where no other special benefits were involved, is inherently discriminatory. They felt such separation indicated the different degrees of importance attached to athletes on the basis of sex.

Response: Comment accepted. The provision of a separate dormitory to athletes of one sex but not the other will be considered a failure to provide equivalent benefits as required by the regulation.

(5) *Comment:* Commentors, particularly colleges and universities, expressed concern that the differences in the rules of intercollegiate athletic associations could result in unequal distribution of benefits and opportunities to men's and women's athletic programs, thus placing the institutions in a posture of noncompliance with Title IX.

Response: Commentors made this point with regard to § 86.6(c) of the Title IX regulation, which reads in part:

"The obligation to comply with (Title IX) is not obviated or alleviated by any rule or regulation of any * * * athletic or other * * * association * * *"

Since the penalties for violation of intercollegiate athletic association rules can have a severe effect on the athletic opportunities within an affected program, the Department has reexamined this regulatory requirement to determine whether it should be modified. Our conclusion is that modification would not have a beneficial effect, and that the present requirement will stand.

Several factors enter into this decision. First, the differences between rules affecting men's and women's programs are numerous and change constantly. Despite this, the Department has been unable to discover a single case in which those differences require members to act in a discriminatory manner. Second, some rule differences may permit decisions resulting in discriminatory distribution of benefits and opportunities to men's and women's programs. The fact that institutions respond to differences in rules by choosing to deny equal opportunities, however, does not mean that the rules themselves are at fault; the rules do not prohibit choices that would result in compliance with Title IX. Finally, the rules in question are all established and subject to change by the membership of the association. Since all (or virtually all) association member institutions are subject to Title IX, the opportunity exists for these institutions to resolve collectively any wide-spread Title IX compliance problems resulting from association rules. To the extent that this has not taken place, Federal intervention on behalf of statutory beneficiaries is both warranted and required by the law. Consequently, the Department can follow no course other than to continue to disallow any defenses against findings of noncompliance with Title IX that are based on intercollegiate athletic association rules.

(6) *Comment:* Some commentors suggested that the equal average per capita test was unfairly skewed by the high cost of some "major" men's sports, particularly football, that have no equivalently expensive counterpart among women's sports. They suggested that a certain percentage of those costs (e.g., 50% of football scholarships) should be excluded from the expenditures on male athletes prior to application of the equal average per capita test.

Response: Since equality of average per capita expenditures has been eliminated as a standard of presumed compliance, the suggestion is no longer relevant. However, it was possible under that standard to exclude expenditures that were due to the nature of the sport, or the scope of competition and thus were not discriminatory in effect. Given the diversity of intercollegiate athletic programs, determinations as to whether disparities in expenditures were nondiscriminatory would have been made on a case-by-case basis. There was no legal support for the proposition that an arbitrary percentage of expenditures should be excluded from the calculations.

(7) *Comment*: Some commentors urged the Department to adopt various forms of team-based comparisons in assessing equality of opportunity between men's and women's athletic programs. They stated that well-developed men's programs are frequently characterized by a few "major" teams that have the greatest spectator appeal, earn the greatest income, cost the most to operate, and dominate the program in other ways. They suggested that women's programs should be similarly constructed and that comparability should then be required only between "men's major" and "women's major" teams, and between "men's minor" and "women's minor" teams. The men's teams most often cited as appropriate for "major" designation have been football and basketball, with women's basketball and volleyball being frequently selected as the counterparts.

Response: There are two problems with this approach to assessing equal opportunity. First, neither the statute nor the regulation calls for identical programs for male and female athletes. Absent such a requirement, the Department cannot base noncompliance upon a failure to provide arbitrarily identical programs, either in whole or in part.

Second, no subgrouping of male or female students (such as a team) mat be used in such a way as to diminish the protection of the larger class of males and females in their rights to equal participation in educational benefits or opportunities. Use of the "major/minor" classification does not meet this test where large participation sports (e.g., football) are compared to smaller ones (e.g., women's volleyball) in such a manner as to have the effect of disproportionately providing benefits or opportunities to the members of one sex.

(8) *Comment:* Some commenters suggest that equality of opportunity should be measured by a "sport-specific" comparison. Under this approach, institutions offering the same sports to men and women would have an obligation to provide equal opportunity within each of those sports. For example, the men's basketball team and the women's basketball team would have to receive equal opportunities and benefits.

Response: As noted above, there is no provision for the requirement of identical programs for men and women, and no such requirement will be made by the Department. Moreover, a sport-specific comparison could actually create unequal opportunity. For example, the sports available for men at an institution might include most or all of those available for women; but the men's program might concentrate resources on sports not available to women (e.g., football, ice hockey). In addition, the sport-specific concept overlooks two key elements of the Title IX regulation.

First, the regulation states that the selection of sports is to be representative of student interests and abilities (86.41(c)(1)). A requirement that sports for the members of one sex be available or developed solely or the basis of their existence or development in the program for members of the other sex could conflict with the regulation where the interests and abilities of male and female students diverge.

Second, the regulation frames the general compliance obligations of recipients in terms of program-wide benefits and opportunities (86.41(c)). As implied above, Title IX protects the individual as a student-athlete, not all a basketball player, or swimmer.

(9) *Comment:* A coalition of many colleges and universities urged that there are no objective standards against which compliance with Title IX in intercollegiate athletics could be measured. They felt that diversity is so great among colleges and universities that no single standard or set of standards could practicably apply to all affected institutions. They concluded that it would be best for individual institutions to determine the policies and procedures by which to ensure nondiscrimination in intercollegiate athletic programs.

Specifically, this coalition suggested that each institution should create a group representative of all affected parties on campus.

This group would then assess existing athletic opportunities for men and women, and, on the basis of the assessment, develop a plan to ensure nondiscrimination. This plan would then be recommended to the Board of Trustees or other appropriate governing body.

The role foreseen for the Department under this concept is:

(a) The Department would use the plan as a framework for evaluating complaints and assessing compliance;

(b) The Department would determine whether the plan satisfies the interests of the involved parties; and

(c) The Department would determine whether the institution is adhering to the plan.

These commenters felt that this approach to Title IX enforcement would ensure an environment of equal opportunity.

Response: Title IX is an antidiscrimination law. It prohibits discrimination based on sex in educational institutions that are recipients of Federal assistance. The legislative history of Title IX clearly shows that it was enacted because of discrimination that currently was being practiced against women in educational institutions. The Department accepts that colleges and universities are sincere in their intention to ensure equal opportunity in intercollegiate athletics to their male and female students. It cannot, however, turn over its responsibility for interpreting and enforcing the law. In this case, its responsibility includes articulating the standards by which compliance with the Title IX statute will be evaluated.

The Department agrees with this group of commenters that the proposed self-assessment and institutional plan is an excellent idea. Any institution that engages in the assessment/planning process, particularly with the full participation of interested parties as envisioned in the proposal, would clearly reach or move well toward compliance. In addition, as explained in Section VIII of this Policy Interpretation, any college or university that has compliance problems but is implementing a plan that the Department determines will correct those problems within a reasonable period of time, will be found in compliance.

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[1] The regulation specifically refers to club sports separately from intercollegiate athletics. Accordingly, under this Policy Interpretation, club teams will not be considered to be intercollegiate teams except in those instances where they regularly participate in varsity competition.
[2] See also § 86.37(a) of the regulation.
[3] 86.41(c)(1) on the accommodation of student interests and abilities, is covered in detail in the following Section C of this policy Interpretation.
[4] See also § 88.41(a) and (b) of the regulation.
[5] Section 844 of the Education Amendments of 1974, Pub. L 93-380, Title VIII, (August 21, 1974) 88 Stat. 612.
[6] The Department's jurisdiction over the employment practices of recipients under Subpart E, §§ 86.51–86.61 of the Title IX regulation has been successfully challenged in several court cases. Accordingly, the Department has suspended enforcement of Subpart E. Section 86.41(c)(6) of the regulation, however, authorizes the Department to consider the compensation of coaches of men and women in the determination of the equality of athletic opportunity provided to male and female athletes. It is on this section of the regulation that this Policy Interpretation is based.
[7] Public undergraduate institutions are also subject to the general anti-discrimination provision at § 86.23 of the regulation, which reads in part:

"A recipient * * * shall not discriminate on the basis of sex in the recruitment and admission of students. A recipient may be required to undertake additional recruitment efforts for one sex as remedial action * * * and may choose to undertake such efforts as affirmative action * * *"

Accordingly, institutions subject to § 86.23 are required in all cases to maintain equivalently effective recruitment programs for both sexes and, under § 88.41(c), to provide equivalent benefits, opportunities, and treatment to student athletes of both sexes.
[8] Those procedures may be found at 45 CFR 80.6—80.11 and 45 CFR Part 8.
[9] *WEAL v. Harris*, Civil Action No. 74-1720 (D.D.C., December 29, 1977).

[1] *The Condition of Education 1979*, National Center for Education Statistics, p. 112.
[2] Figure obtained from Association for Intercollegiate Athletics for Women (AIAW) member survey, *AIAW Structure Implementation Survey Data Summary*, October 1978, p. 11.
[3] U.S. Commission on Civil Rights, Comments to DHEW on proposed Policy Interpretation; Analysis of data supplied by the National Association of Directors of Collegiate Athletics.
[4] Figures obtained from National Federation of High School Associations (NFHSA) data.
[5] *Digest of Education Statistics 1977–78*, National Center for Education Statistics (1978), Table 40, at 44. Data, by sex, are unavailable for the period from 1971 to 1977; consequently, these figures represent 50 percent of total enrollment for that period. This is the best comparison that could be made based on available data.
[6] Ibid, p. 112.
[7] These figures, which are not precisely comparable to those cited at footnote 2, were obtained from *Sports and Recreational Programs of the Nation's Universities and Colleges*, NCAA Report No. 5, March 1978. It includes figures only from the 722 NCAA member institutions because comparable data was not available from other associations.
[8] Compiled from *NCAA Revenues and Expenses for Intercollegiate Athletic Programs*, 1978.
[9] Figures obtained from *AIAW Structure Implementation Survey Data Summary*, October, 1978, p. 11.
[10] 121 Cong. REc. 29791–95 (1975) (remarks of Senator Williams); Comments by Senator Bayh, Hearings on S. 2106 Before the Subcommittee on Education of the Senate Committee on Labor and Public Welfare, 94th Congress, 1st Session 48 (1975); "Survey of Women's Athletic Directors," AIAW Workshop (January 1978).
[11] See April 18,1979, Opinion of General Counsel, Department of Health, Education, and Welfare, page 1.

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ED Data Express (https://eddataexpress.ed.gov/?src=ft)
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What Works Clearinghouse (https://ies.ed.gov/ncee/wwc/?src=ft)
Open Data Platform (https://data.ed.gov/?src=ft)
COVID Relief Data (https://covid-relief-data.ed.gov/?src=ft)

About Us
(/about/?src=ft)
Contact Us (/about/contacts/gen/?src=ft)
ED Offices (/about/offices/list/?src=ft)
Jobs (https://www.ed.gov/jobs/?src=ft)
Press Releases (https://www.ed.gov/news/?src=ft)
FAQs (https://www.ed.gov/answers/?src=ft)
Recursos en español (/espanol/bienvenidos/es/index.html?src=ft)
Budget, Performance (/about/overview/focus/performance.html?src=ft)

EXHIBIT 7

WILENCHIK & BARTNESS
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2022 AAU National Championship Jr Olympics Results (random selected results from 2022 Track & Field comparing top finishers)

http://image2.aausports.org/sports/athletics/results/2022/jogames/jogamescompleteresults.htm

Girls 100 Meter Dash 8-under:14.41
Boys 100 Meter Dash 8-under:**13.87**

Girls 100 Meter Dash 9 years old:13.37
Boys 100 Meter Dash 9 years old:**12.86**

Girls 100 Meter Dash 10 years old:13.02
Boys 100 Meter Dash 10 years old:**12.43**

Girls 100 Meter Dash 11 years old:12.77
Boys 100 Meter Dash 11 years old:**12.18**

Girls 200 Meter Dash 8-under:29.64
Boys 200 Meter Dash 8-under: **28.56**

Girls 200 Meter Dash 9 years old:27.64
Boys 200 Meter Dash 9 years old:**26.55**

Girls 200 Meter Dash 10 years old:27.12
Boys 200 Meter Dash 10 years old:**25.32**

Girls 200 Meter Dash 11 years old:**25.64**
Boys 200 Meter Dash 11 years old:25.73

Girls Shot Put 4 lbs 8-under: 23-04.75
Boys Shot Put 4 lbs 8-under: **31-01.00**

Girls Shot Put 6 lbs 9 years old:25-10.25
Boys Shot Put 6 lbs 9 years old:**31-06.75**

EXHIBIT 8

WILENCHIK & BARTNESS
A PROFESSIONAL CORPORATION

AAU Junior Olympics All Time Records:

The Junior Olympics posts track & field all-time records dating back to 1980. For example, they keep the all-time best for "Girls 100 Meter Dash 8 Years and Under". The all-time records frame boys under the age of 11 historically outperform the highest performing girls in an identical sporting event such as running. There are two cases where girls have set a record over a boy in Junior Olympics Track & Field (Girls/Boys 1500 Meter Race Walk 11 years old & Girls/Boys Javelin Throw Turbo 9 years old).

https://image.aausports.org/dnn/athletics/Boys-National-Records.pdf
https://image.aausports.org/dnn/athletics/Girls-National-Records.pdf

Girls 100 Meter Dash 8-under: 13.86
Boys 100 Meter Dash 8-under: **13.46**

Girls 100 Meter Dash 9 years old: 13.23
Boys 100 Meter Dash 9 years old: **12.86**

Girls 100 Meter Dash 10 years old: 12.76
Boys 100 Meter Dash 10 years old: **12.43**

Girls 100 Meter Dash 11 years old: 12.45
Boys 100 Meter Dash 11 years old: **12.04**

Girls 200 Meter Dash 8-under: 28.29
Boys 200 Meter Dash 8-under: **27.80**

Girls 200 Meter Dash 9 years old: 27.55
Boys 200 Meter Dash 9 years old: **26.46**

Girls 200 Meter Dash 10 years old: 26.05
Boys 200 Meter Dash 10 years old: **25.25**

Girls 200 Meter Dash 11 years old: 25.14
Boys 200 Meter Dash 11 years old: **24.69**

Girls 400 Meter Dash 8-under: 1:05.04
Boys 400 Meter Dash 8-under: **1:03.44**

Girls 400 Meter Dash 9 years old: 1:01.60
Boys 400 Meter Dash 9 years old: **59.25**

Girls 400 Meter Dash 10 years old: 59.37
Boys 400 Meter Dash 10 years old: **55.74**

Girls 400 Meter Dash 11 years old: 57.07
Boys 400 Meter Dash 11 years old: **55.51**

Girls 800 Meter Run 8-under: 2:32.00
Boys 800 Meter Run 8-under: **2:27.02**

Girls 800 Meter Run 9 years old: 2:26.36
Boys 800 Meter Run 9 years old: **2:19.43**

Girls 800 Meter Run 10 years old: 2:22.51
Boys 800 Meter Run 10 years old: **2:16.44**

Girls 800 Meter Run 11 years old: 2:19.27
Boys 800 Meter Run 11 years old: **2:11.58**

Girls 1500 Meter Run 8-under: 5:18.44
Boys 1500 Meter Run 8-under: **5:07.14**

Girls 1500 Meter Run 9 years old: 5:08.05
Boys 1500 Meter Run 9 years old: **4:42.97**

Girls 1500 Meter Run 10 years old: 4:54.59
Boys 1500 Meter Run 10 years old: **4:46.84**

Girls 1500 Meter Run 11 years old: 4:45.65
Boys 1500 Meter Run 11 years old: **4:37.24**

Girls 3000 Meter Run 11 years old: 10:22.97
Boys 3000 Meter Run 11 years old: **9:48.26**

Girls 1500 Meter Race Walk 9 years old: 8:08.02
Boys 1500 Meter Race Walk 9 years old: **7:53.71**

Girls 1500 Meter Race Walk 10 years old: 7:46.29
Boys 1500 Meter Race Walk 10 years old: **7:33.06**

Girls 1500 Meter Race Walk 11 years old: **7:17.80**
Boys 1500 Meter Race Walk 11 years old: 7:31.34

Girls 80 Meter Hurdles 11 years old: 12.49
Boys 80 Meter Hurdles 11 years old: **12.10**

Girls Long Jump 8-under: 13-08.25
Boys Long Jump 8-under: **14-09.75**

Girls Long Jump 9 years old: 14-11.50
Boys Long Jump 9 years old: **15-07.50**

Girls Long Jump 10 years old: 15-10.25
Boys Long Jump 10 years old: **16-10.75**

Girls Long Jump 11 years old: 17-02.50
Boys Long Jump 11 years old: **18-01**

Girls High Jump 9 years old: 4-04
Boys High Jump 9 years old: **4-06**

Girls High Jump 10 years old: 4-10
Boys High Jump 10 years old: **5-00**

Girls High Jump 11 years old: 5-00
Boys High Jump 11 years old: **5-02.25**

Girls Discus Throw 1.0 kg 11 years old: 100-04
Boys Discus Throw 1.0 kg 11 years old: **108-11**

Girls Shot Put 4 lbs 8-under: 28-05.75
Boys Shot Put 4 lbs 8-under: **34-10**

Girls Shot Put 6 lbs 9 years old: 30-01.50
Boys Shot Put 6 lbs 9 years old: **37-01.50**

Girls Shot Put 6 lbs 10 years old: 34-00
Boys Shot Put 6 lbs 10 years old: **42-04**

Girls Shot Put 6 lbs 11 years old: 40-05.75
Boys Shot Put 6 lbs 11 years old: **48-11.25**

Girls Javelin Throw Turbo (300 g 8-under: 78-04
Boys Javelin Throw Turbo (300 g 8-under: **98-04**

Girls Javelin Throw Turbo (400 g 9 years old: **95-00**
Boys Javelin Throw Turbo (400 g 9 years old: 94-07

Girls Javelin Throw Turbo (400 g 10 years old: 99-02
Boys Javelin Throw Turbo (400 g 10 years old: **111-05**

Girls Javelin Throw Turbo (400 g 11 years old: 104-00
Boys Javelin Throw Turbo (400 g 11 years old: **138-03**

Girls 4x100 Meter Relay 8-under: 59.08
Boys 4x100 Meter Relay 8-under: **55.35**

Girls 4x100 Meter Relay 10 years old: 53.12
Boys 4x100 Meter Relay 10 years old: **51.16**

Girls 4x400 Meter Relay 10 years old: 4:20.87
Boys 4x400 Meter Relay 10 years old: **4:07.29**

Girls Triathlon 9 years old: 1134
Boys Triathlon 9 years old: **897**

Girls Outdoor Pentathlon 11 years old: 3081
Boys Outdoor Pentathlon 11 years old: **2836**