THESIS

SPORTS PARTICIPATION AS A SOCIAL DETERMINANT OF ATHLETIC SEX DIFFERENCES

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ABSTRACT

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ATHLETIC SEX DIFFERENCES

The belief in a substantial gap in physical ability between men and women is one of the primary justifications for sex segregation in athletic competitions. However, limited attention has been paid to the gendered social forces that may be influencing these differences. This study asks whether gender differences in sports participation affect performance differences, examining high school track and field data covering 17 US states from 1979-2019 of state-level participation and corresponding state championship-winning performances across 5 events. Results show that for the 100m, 800m, 1600m, and pole vault, increased girls' participation predicts twice as much performance improvement as for boys, though no significant effects were found for high jump. Direct comparisons of gender gaps in participation to gender gaps in performance for each state show significant effects for the 100m ($p<0.05$), and no significant effects for the other four events. The findings suggest that increasing current participation levels of girls in high school track and field to equal boys' participation would decrease the gap in performance, though not erase it entirely, indicating that sports participation is one of multiple factors affecting gender differences in athletic performance. Based on these findings, I argue current sex differences in athletic abilities should not be attributed entirely to innate sex differences and that researchers should further consider the effects of social inequalities on sports participation and physical development.

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INTRODUCTION

At a gathering of feminist activists in 1972, Billie Jean King remembers asking Gloria Steinem "why she didn't use more athletes to promote equality. She said, 'Billie, this is about politics.' I told her, 'Gloria, we are politics.'" (King 2021). As King knew, the presence of women in the world of sports has constituted a fundamentally political relationship throughout modern history. This remains a pressing political problem today.

In the last 150 years, organized sports have become increasingly omnipresent in everyday life as pastimes, entertainment, and professional careers. However, organized sports are not neutral institutions, nor are they separate from the rest of society. Almost all modern sports are categorized into men's sports (often referred to as just 'sports') and women's sports. This practice of gendering sports constructs, normalizes, and enforces assumed male superiority, both socially and legally, based on the idea that men are biologically advantaged in sport over women (McDonagh and Pappano 2008:4). The belief that the male body is superior is "one of the key elements in maintaining men's overall power over women" (Messner 1992:15). Even though the notion of gender equality has become a widespread ideal, "gender divisions and men's superiority are more naturalized in sport than perhaps any other institution" (Love and Kelly 2011).

Sports are used to reassert dominant ideologies of male hegemony. Kane (1995:192) writes that when "symbols and institutions of male supremacy" weaken or are put into flux, sport provides "incontrovertible evidence of male superiority." We can see this happening today. As gender non-conforming identities and behaviors grow in visibility and acceptance, a force of backlash is rising at the same time, with a particular focus on sports. President Donald Trump signed an

executive order on February 5, 2025 stating, “It shall also be the policy of the United States to oppose male competitive participation in women’s sports more broadly, as a matter of safety, fairness, dignity, and truth” (Anon 2025). Most Americans seem to support this as well, with an estimated 66% of U.S. adults in 2025 favoring restricting transgender athletes to competing on teams matching their assigned sex at birth, up from 58% in 2022 (Pew Research Center 2025). This movement uses arguments of biological determinism and fairness to both exclude trans athletes and reinforce (cis) male superiority across the board. Given these consequences, the link between biological sex and athletic ability warrants thorough scrutiny.

The interaction between gender inequality and sports is deeply intertwined with sports as an institution, and as such we can analyze its practices as processes reproducing and maintaining gender inequality among other forms. Just as corporate organizations have myths that justify existing inequalities, so do sporting organizations (Amis, Mair, and Munir 2020). Further investigating the justification, legitimation, and reproduction of inequality in sports can help broaden our understanding of these workings.

Part of these institutional practices involve boundary-making separating men from women in sports physically, culturally, and symbolically, all reinforcing the view of gender as what Kane (1995) terms an “oppositional binary.” One of the main justifications of institutional gender inequality in sports is the assumption that male bodies are naturally and categorically advantaged to female bodies. This study seeks to investigate this claim. Given that much of what is defined as gender stems from socially constructed norms and boundaries and not biological sex characteristics, this study asks whether gendered social forces contribute to sex-attributed differences in athletic ability in a meaningful way. The following study is a quantitative analysis

of the effects of gender differences in high school track and field participation on resulting top performance differences at the state level from 1979 through 2019.

The first section will provide background on the ways gender and sports have shaped each other from a sociological perspective as well as what previous research has established about athletic sex differences. The second section outlines the methods for collecting, cleaning, and analyzing the data. The third section describes the statistical analysis of the participation and performance data. Finally, the fourth section discusses the implications and limitations of the findings as well as potential avenues for future research.

LITERATURE REVIEW

Introduction

In discussing forms of justice, Nancy Fraser (2001:99) describes the establishment of 'civil union' laws in place of same-sex marriage as establishing a "second, parallel legal status … that fails to confer all the symbolic or material benefits of marriage, while reserving the latter, privileged status exclusively for heterosexual couples," and because of this these laws do not "fulfill the requirements of justice as understood via the status model." In the same vein, I argue the practice of segregating sports into men's and women's sports also establishes this "second, parallel legal status" failing to "confer all the symbolic or material benefits" reserved for men's sports and is thus, under these terms, an unjust system.

The practice of sex segregation in sports is fundamentally based on the premise of a sex binary and related assumptions about oppositional sex categories and unfair physical differences between them. The belief in male superiority and female inferiority that this system constructs is "one of the most central and coveted beliefs in sport" (Dworkin and Cooky 2012:21). Given the real-world effects of the current system on social practices, further scrutiny is warranted into the origins and ideological foundations of the sex differences in physical performance as these provide the logical underpinning of sex segregation and classification in sports.

Accompanying sex segregation is a broader pattern of sex testing and classification policies that have existed in competitive sports for decades, including such methods as chromosomal testing and visual inspection of genitalia (Bostwick and Joyner 2012). These tests, only applied to women's competitions, often occur after an exceptional performance by a woman is met with

suspicion about her sex. Caster Semenya, a Black South African runner, for example, was subjected to comprehensive sex testing that could revoke her 2009 world championship win after her "broad shoulders" and other "masculine cues" provoked rumors by competing runners that she was "not a woman" (Bostwick and Joyner 2012:508). Sex testing women reinforces the cultural idea that stellar athletes cannot be 'real' women, while no such belief is applied to men (Dworkin and Cooky 2012). A result of these policies is that women with higher than allowed testosterone levels are often not classified to compete in men's category but are fully excluded from competition. Dutee Chand, a high-level Indian sprinter, for instance, was banned from competition by the then-called International Amateur Athletics Federation (IAAF, now World Athletics) for "having elevated testosterone levels which were argued to provide her with an unfair advantage" (Kerr and Obel 2018:8). Sex testing is one of the more salient ways that sex segregation is enforced via the restriction and policing of women's bodies, all based on the premise that variations in testosterone provide unfair advantage against other women.

The following section will provide an overview of sex segregation in sports, current issues this poses for transgender and nonbinary athletes, the sex binary, and measured sex differences supporting these regulations. Then we will consider the gendered history and social context surrounding women in sports as well as an overview of social factors potentially creating and reinforcing physical differences in athletics.

Sex Segregation

Legislating around gender is only necessary because nearly all sports are segregated into two mutually exclusive sex categories. Sex segregation refers to the established practice of operating separate sporting opportunities and competitions between athletes deemed male and those deemed female. McDonagh and Pappano (2008) specify that what operates in modern sports is a

practice of *coercive* sex segregation, as even a qualified female athlete who wanted to play with boys would not be allowed to. Such a system is justified as not only acceptable but necessary on the basis "not merely that males and females are physically different, but that females are physically, if not emotionally and otherwise, inferior to males when it comes to sports" (McDonagh and Pappano 2008:15). This practice can be better understood within the broader history of sports, gender, and other social boundaries.

A Brief History of Sex Segregation in Sports

In the modern history of sports, women largely have been either segregated from men or excluded entirely, but gender was only one of the many social barriers put in place. Early American sports starting in the 1890's involved segregation around race and class in addition to gender (McDonagh and Pappano 2008). For example, Black baseball players in America were banned from competing with white players from the 1880's through the mid-20th century (Park and Huggins 2022). Additionally, many middle-class rowing, golfing, cycling, and tennis clubs in late-19th century Britain and America imposed high membership fees, "confidential" reference systems, or even explicitly barred working class artisans and laborers (Park and Huggins 2022:149). Occasionally, women would be allowed, though there would often be more restrictive rules on dress and length of competition (McDonagh and Pappano 2008; Park and Huggins 2022). Within this context, gender segregation emerged primarily as a mechanism of social exclusion.

Sport has been used as a tool of social organization throughout its history, particularly around gender roles and reinforcing their distinction. Organized sports in Western industrializing societies grew out of fears of men and boys' feminization as (mainly white) men started to move

from agricultural to factory work away from home, leaving boys to grow up only around their mothers (Messner 1992). At the same time, women were actively discouraged from physical activities entirely, as doctors worried that too much exertion might "dislodge the uterus" or "entail lifelong misery" (McDonagh and Pappano 2008:166).

Despite these institutional and ideological barriers, many women did participate in sports. The first intercollegiate women's basketball game in the US occurred in 1896 between Stanford University and the University of California (Park and Huggins 2022). Bicycle riding also became quite popular among women around this time and grew into a symbol of their independence, with Susan B. Anthony even stating that the bicycle had done more than anything else to emancipate women (Park and Huggins 2022). In 1880's Britain, some cycling clubs admitted women while others had "special ladies' sections" or were just for women (Hargreaves 2002:94). Public swimming, however, was rigidly separated by sex until at least the 1920's on the grounds of "modesty and morality" (Hargreaves 2002:97).

A significant shift in policy, particularly in the United States, emerged with Title IX of the Education Amendments Act of 1972. The legislation was designed to "prohibit sex discrimination in educational programs receiving federal support" and reduce inequality by mandating an equal number of opportunities and (theoretically) equal access to resources (McDonagh and Pappano 2008:29). This had major results in increasing access to women's sports. In 1971, an estimated 1 high school girl played sports for every 12 boys, and by 2013 this ratio was 1 to 1.39 (Acosta and Carpenter 2014).

While Title IX certainly raised the floor for gender equality in sports, it may have also allowed for a ceiling preventing complete equality. The law, as Travers (2009) argues, reinforced

inequality by legislating “the distinct and inferior status” of women as athletes. The law explicitly allows sex segregation when selection is based on “competitive skill” and in any activity deemed a “contact sport” (Title IX 2018). These regulations allowed and thus paved the way for an explicit system of segregated sports (McDonagh and Pappano 2008). The history of women’s sports prior to the 1970’s showed many instances of sex segregation but also possibilities for sex integration. The law’s passage, in allowing for sex segregation to continue, cemented the institutional practice into the American sports structure.

Althusser (1971) writes, “Ideology represents the imaginary relationship of individuals to their real conditions of existence.” The historical context of women in sports invites questions into whether the idea of sex differences resulting in unfair advantage represents more of an ideological legitimation of sex segregation than a purely objective reality. As will be discussed in further sections, this segregated sports system is both attributed to the idea of binary sex differences and also creates and reinforce these differences and their linked constructions of sex and gender.

Trans Athlete Bans

In addition to long-standing issues of gender inequality, the existence of transgender athletes, particularly transgender women, directly challenges the system of binary categorization that often conflates gender and sex and thus poses an acute problem with systems of sex segregation. This, combined with beliefs in categorical difference between male and female bodies, has led to restrictions and exclusions of transgender women in sports to define who can count as a woman to compete in women’s sports categories.

The International Olympic Committee (IOC) first allowed transgender women to compete in the women's category in 2004 under the restrictive conditions of a legal sex change, "gonadectomy," and two years of hormone therapy post-surgery (Harper 2023:106; Sykes 2006). The NCAA and International Amateur Athletics Federation (IAAF, now World Athletics) later followed, allowing transgender women to compete with one year of hormone therapy in 2011 (Harper 2023:106). As scientific sex research began to focus more on hormone levels, the IOC in 2016 adopted a 5 nmol/L testosterone limit, with the IAAF following in 2019 (Harper 2023).

For all the attention paid to such matters, there have, especially until recently, been few transgender athletes competing at the highest levels. The first openly transgender athletes in the Olympics competed in 2020: New Zealand weightlifter Laurel Hubbard, a then 43-year-old transgender woman who placed last; Canadian soccer player Quinn, a nonbinary player who won gold with the women's team; and nonbinary skateboarder Alana Smith (Harper 2023:110).

In 2021, the IOC proclaimed that restrictions are only appropriate once "robust and peer reviewed" sport-specific research becomes available, and that "there should be no presumption of advantage held by any trans athlete" (Harper 2023:111). In a contrasting direction, World Athletics (formerly IAAF) announced in March 2023 a new policy banning all transgender women "who have been through male puberty" from female competition rankings and restrict testosterone levels for cisgender women to be at most 2.5nmol/liter for at least the preceding two years (Anon 2023).

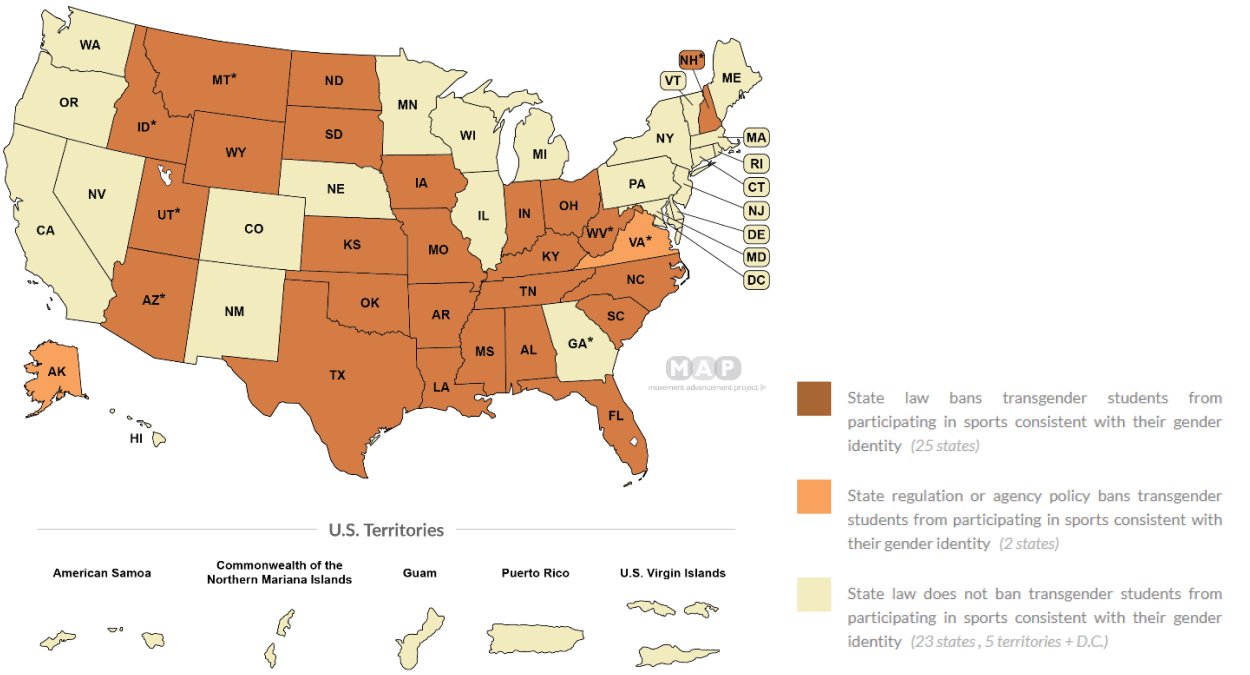

Figure 1: Restrictions on Transgender School Sports Participation as of January 10, 2025 (Movement Advancement Project 2025)

Sports in educational settings are also facing increasing gender-based restrictions. According to the Movement Advancement Project, at least 25 states (see Figure 1) have banned transgender students from participating in school sports consistent with their gender identity (Movement Advancement Project 2025). In 2022, South Dakota passed a law restricting girl's and women's sports participation in all schools to "only female athletes, based on their biological sex" (The Committee on State Affairs at the request of the Office of the Governor 2022). Alabama and Mississippi both passed similar laws in 2021 (Chandler 2021; Wagster Pettus 2021). Current federal policy following the February 5, 2025 executive order titled "Keeping Men out of Women's Sports" seeks to restrict girl's and women's sports at all federally-funded school to only athletes assigned female at birth (Anon 2025). The NCAA officially changed its policy to align with that of the executive order only one day after the order was signed (Media Center 2025).

Each of these restrictions and legislations is fundamentally organized under the premise of sex segregation and the normative justification that female athletes must be segregated or "protected" away from males. For example, in a 2023 press release, World Athletics president Sebastian Coe justified the decision to ban transgender women by stating "we believe the integrity of the female category in athletics is paramount." (Anon 2023). If this strict segregation of sex were not necessary, issues relating to the incorporation of athletes outside the gender binary would become moot. For this reason, the theoretical and empirical foundations underlying the belief in categorical sex difference needs to be more thoroughly investigated.

The Sex Binary

Legislating around sex segregation rests on the premise of the sex binary, so it is important to interrogate its meaning. Sex is defined as "a biological concept having to do with chromosomes, genitalia, gonads, and hormones" (Oberlin 2023:2). These various biological characteristics are used to construct a binary distinction that classifies all humans as male or female. However, while these commonly noted sex characteristics may follow a bimodal pattern, they do not follow an exact binary. Among chromosomes, XX and XY are by far the most common, but natural genetic mutations have led to combinations including "XXX, XXY, XYY, XXXX, XXYY, XXXY, XXXXY, or even XXXXX" (Oberlin 2023:2).

Current research on "sex" hormones suggests a bimodal distribution of testosterone levels, with females having polycystic ovarian syndrome (PCOS) or congenital adrenal hyperplasia showing higher testosterone levels than the "normal female range" while still being "below the normal male range" (Clark et al. 2019). Even at the most fundamental level, there is no exact division between what we consider male and female at the genetic and hormonal levels, much less how this presents in our physical bodies.

The concept of sex as a mutually exclusive, oppositional binary is ultimately cultural and ideological. Among the spectrum of human genetic phenotypes, it is true that there are general patterns, but the line dividing these (always imperfectly) into two mutually exclusive categories is a social construction with significant consequences. These constructions then inform the kind of research that is done, and the kinds of conclusions that are drawn from it. Through decades of imperfect methods in sex classification research moving from genitalia to gonads to chromosomes to hormones to genetics, "the assumption that sex is a binary was never questioned because it was never a hypothesis: it was the taken-for-granted starting point" (Sanz 2017:20). It is not a given that there are two and only two sexes. Fausto-Sterling (1993) even argues that the wide variety of intersex variations outside of traditional male/female conceptions warrants naming five sexes rather than just two. These binary assumptions inscribed into daily life as they are used to draw sex categories in sporting competitions, often leading to invasions of privacy and public exclusions when athletes, most often cis- and transgender women, fall outside of the presumed boundaries.

The sex binary is constructed in sports and justified on the grounds that sex characteristics are presumed to significantly affect physical development, so the degree of difference in the abilities of all males and females is too large to engage in fair competition. There are at least some cases, however, where measured sex differences cannot reasonably explain sex/gender segregation in sporting competition. Shooting is a sport in which no measurable differences in performance are observed between men and women, and women have beaten men in non-segregated competition (Goldschmied and Kowalczyk 2016). In fact, women have succeeded at the highest levels of competition against men. In 1976, Margaret Murdock won the gold medal in Rifle shooting at the Pan American Games (McDonagh and Pappano 2008:12). In the 1992 Olympics, Zhang Shan

won gold in skeet shooting competing against both men and women (Love and Kelly 2011). However, she was unable to defend her title in 1996 because the event had been designated men's only, and by 2000 there was a separate women's competition (Love and Kelly 2011).

Such examples suggest that sex segregation is motivated not just by sex differences but also by gender, that is the "social structures or meaning systems" that create the idea of men and women, what they are, and what they do (Harding 2006:68). As seen in the previous section, the historical context of sports, as well as who can play them and how, is inextricably intertwined with social structures defining who men and women are and what men and women should be.

What are the ways that sex differences in athletic abilities are currently measured? Biological determinants of athletic sex differences are attributed mainly to males having larger muscle mass, less relative body fat, and larger heart size, airways, and lung volume, with these primarily thought to be caused by higher levels of testosterone in boys at puberty than in girls (Hilton and Lundberg 2021; Hunter et al. 2023:2349).

Average sex differences in elite running performances have been measured in adults, finding significant average differences among top male and female performers, especially in track and field. A study of IAAF world championship winners from 1983-2015 reported a mean difference between men and women winners of 8.2 ± 1.0% – 11.8 ± 2.1% for sprints, 10.3 ± 3.3% – 12.8 ± 4.0% for the middle and long-distance events, and 14.2 ± 2.2% – 25.0 ± 4.4% for jumps (Ospina Betancurt et al. 2018:7). Another found an average sex difference in world record running performances of 7.3-10.5% for sprints and 8.4-14.1% for distance races (Cheuvront et al. 2005:1020). While such studies acknowledge that societal influences like sports participation and training "probably made the largest historical impact," they ultimately conclude that "present-

day sex differences in running performance appear to be of biological origin" (Cheuvront et al. 2005:1020-22).

This "muscle gap" has experienced changes over time, however. For example, the sex gap in running performance closed rapidly as women increasingly competed in high level sport, although comparative rates of improvement have plateaued for women since the mid 1980's, leading some to conclude the remaining performance differences must be due to biological differences (Thibault et al. 2010). However, as will be expanded on in later sections, the social changes that preceded this narrowing of the sex gap also plateaued in many respects. This pattern is likely to have some effect on current measured performance differences by sex. We have not yet reached full gender equality on the social level, including pay and political representation, which invites questions on whether such conclusions are premature (Aragão 2023; Dittmar 2019).

As Kane (1995:202) argues, there is a "fundamental assumption" underlying the muscle gap that "men are, by definition, inherently superior in the sports that matter most." This assumption has material effects, including in the institution of law. For example, a 1981 court ruling upheld a policy barring an Arizona high school boy from joining his school's volleyball team on the grounds that, "due to average physiological differences, males would displace females to a substantial extent if they were allowed to compete for positions on the volleyball team" and thus "males would have an undue advantage competing against women for positions on the volleyball team" (Love and Kelly 2011:237).

The belief in an inherent, biological performance gap is the primary scientific support for continuing sex segregation extends to trans athletes as well. In a rebuttal to the IOC 2021

decision to ....a recent paper by twenty-six renowned sport scientists, argued for an inclusive, "evidence-based" approach with "no presumption of advantage", maintaining that "it must be recognized that the size of the male biological advantage, and the number of males who compete in most sports, makes it extremely unlikely than any female would ever win medals at the highest level without the protection of a closed category that excludes male advantage" (Lundberg et al. 2024:5).

If, however, the male biological advantage was partly or entirely a product of decades of gender discrimination rather than innate sexual dimorphism, the cause of unfairness itself may be the system of hierarchical sex segregation that perpetuates unequal recognition and access to female athletes that might reach a level where they could win a medal against a man but aren't allowed to try.

Against the 'Muscle Gap'

Some researchers are critical of focusing too much on binary measures of physical difference. Kane (1995:198) critiques this 'muscle gap,' arguing that focusing on the difference between the average man and average woman obscures any overlap and reconfirms gender as two distinct categories-- it assumes "only one muscle gap versus many muscle gaps." By only measuring average running, swimming, or strength differences between adult males and females, we are ignoring the many other ways that our bodies and abilities vary and overlap. There is a "fundamental assumption" underlying the muscle gap that "men are, by definition, inherently superior in the sports that matter most" (Kane 1995:202). Instead of conceptualizing sex-based 'muscle gaps' through a lens of oppositional, mutually exclusive difference, Kane argues that it may be more accurate to measure physical variation as continuum. The sport continuum, as she

names it, is the proposition that "many women routinely outperform most—if not all—men in a variety of sports and physical skills/activities," and that "the acknowledgment of such a continuum could provide a direct assault on traditional beliefs about sport—and gender itself—as an inherent, oppositional binary that is grounded in biological difference" (Kane 1995). Currently, institutional sex segregation all but eliminates any opportunity to see the sport continuum in practice, meaning that the overlap in abilities of male and female athletes is effectively erased from public view. This ultimately reinforces the beliefs in categorical sex difference that legitimate sex segregation and gender inequality. While the criticisms of the muscle gap as prioritizing difference have merit, it is still the focus of debate among institutional decision-makers and academic researchers and thus deserves continued attention.

Biology or Society?

A second critique of the muscle gap focuses on its origins. When sex differences in physical abilities and athletic performance are used as justification to regulate sports by sex, the underlying assumption is that these sex differences originate in biology and that this means they are innate and unchanging. Hunter et al. (2023:2328) write, "In athletic events and sports relying on endurance, muscle strength, speed, and power, men typically outperform women because of fundamental sex differences dictated by their sex chromosomes and sex hormones at puberty, in particular, testosterone." However, the physical biology of human bodies is also affected by our actions and environment. Babies do not pop out of the womb with the physiques of Olympic champions.

Research suggests there are social gender dynamics affecting performance abilities. These *sex* differences may be, to some extent, *gender* differences in that there are social factors due to

gender affecting athletic abilities, not just biological. We live in a society where gender is omnipresent. Oberlin (2023:3) writes that we cannot be certain that the sex differences we see are not the result of "sociologic differences," citing differences in physical activity between young males and females. There is no cultural vacuum to study sex differences, so any measurements of muscle gaps cannot rule out social effects (Travers 2009:91). If current sex differences were partially or entirely the result of social gender inequality rather than innate biological difference, then efforts to increase fairness and success would prioritize inclusion and access over exclusion and segregation. The following discussion will describe how gender, and gender inequality, are ingrained in the history of sports and thus lead to socially borne differences in the ways men and women experience the world physically.

Sports as a Gendered Institution

Modern organized sports have never been neutral. Sports, as a structure, is a gendered institution. Acker (1992:567) defines a gendered institution as one where "gender is present in the processes, practices, images and ideologies, and distributions of power in the various sectors of social life." Viewing sports as an institution allows us to see the overarching practices, patterns, and discourses that shape interactions and legitimate beliefs. As will be demonstrated, organized sports represent a deeply gendered institution.

Historically, men have been categorically pushed into sport while women have been pushed out. In the West, the rise of sports coincided with both the industrial revolution but also the first wave of the women's movement. Sports were created to counter "men's fears of feminization" and have since been a key way for men to maintain power over women by positioning the male body as superior (Messner 1992:14). Modern sports were deliberately and politically designed to socialize boys into "good industrial workers" who "reject all but a narrow definition of

masculinity" (Anderson 2009:6). Since its inception, sports in the modern age have not just excluded women but have been an active construction of gender difference and ideological control. This kind of perspective on the embedded nature of sports suggests to us that a sporting institution free of male domination will require significant rework, if one can exist at all.

Western sports were designed for male bodies (Lorber 1993:572). Among the spectrum of human ability, the most culturally prized sports value those such as upper-body strength, large size, and explosive speed. In the words of English (1978), "if women had been the historically dominant sex, our concept of sport would no doubt have evolved differently. Competitions emphasizing flexibility, balance, strength, timing, and small size might dominate Sunday afternoon television and offer salaries in six figures. Men could be clamoring for equal press coverage of their champions."

Even if many sports prioritized traits more likely among males, men were not the only ones eager to play. When sports like basketball, golfing, and cycling were first introduced in the late 19th century, women had to be forced out to keep them from playing, with sport clubs banning women and male cyclists often trying to run female cyclists off the road (Nelson 1994:16). In response to women's increasing athleticism, men barred women from most sport clubs and mocked athletic women (Nelson 1994:16). An English writer in 1881 feared that allowing women to box would make them "horny-handed, wide-shouldered, deep-voiced," with large biceps and argued to "let our women remain women" (Nelson 1994:17). To remain women meant to remain weak.

The current context of sports shows that, while there has been an increasing presence of women, there is still deeply entrenched inequality. In the United States as well as many other countries,

women's access and participation in sports have increased dramatically in the last 50-100 years. Girls' participation in U.S. high school sports rose from under 5% of girls enrolled in 1972 to about 33% in 1999, though boys' participation rates were around 50% the whole time (Stevenson 2007). Today, high school girls still make up only 42.4% of all high school athletes (The National Federation of State High School Associations 2024).

While youth sports participation is nearing numerical parity, the cultural center of mainstream professional sports in the U.S. have not. In the four major professional sports leagues (NFL, MLB, NBA, NHL), there are no women participating (Anderson 2009:5). This appears to still be the case today. At least two women have been drafted into the NBA in 1969 and 1977 (Anon 2024b; Feinberg 2022); however, since the creation of the Women's National Basketball Association (WNBA), it is highly unlikely this will happen again (Anon n.d.). No woman has played in the NFL (Roche 2023). Designating which sports matter most is a cultural process that reflects societal beliefs about gender. As women have made ground in sports like distance running, men have gravitated more towards sports like American football that most exaggerate differences between men and women, a process which creates a cultural context that prioritizes specific forms of masculinity and the traits associated with it.

The gendered context surrounding sports shows us that while there are measured physical differences, this has only occurred in a deeply unequal environment that has privileged the male body over the female, and, as will be discussed further in the next sections, has been characterized by decades of inequality in access and recognition to sporting opportunities. Therefore, there is a real likelihood that this social context has affected women's physical abilities relative to men's on a population level, and we will see empirical support for this in the following section.

Social Determinants of Athletic Sex Differences

While binary sex differences are measurements of the body and what the body can do, the body is affected by social context. Our bodies are affected by our environment and actions, and our environments and actions are "shaped and constrained through cumulative social practices, structures of opportunity, wider cultural meanings, interactions with others, and more" (Dworkin 2001:333). This section will describe current knowledge of how social gendered forces affect our bodies and physical abilities.

Gender as a social force shapes the way we physically exist in the world. In response to a study of the differences in how 5-year-old boys and girls threw a ball, Young (1980) argues that the way that women move about in the world is not due to anatomy or physiology but to the "particular situation of women as conditioned by their sexist oppression in contemporary society" (152). This is because the feminine body is objectified, which causes self-consciousness and distancing from the body (Young 1980:154). When girls are socialized to act and comport themselves in different ways to boys, this affects the ways we learn how to use our bodies, which could result in different or lesser sports-related abilities.

There is empirical evidence to support this. A study of 7- to 12-year old children found that while gender differences were consistent with previous studies when children threw a ball with their dominant hand, those differences largely disappeared when they used their nondominant hand, suggesting that gender differences in throwing are likely learned rather than innate (Williams, Haywood, and Painter 1996). This invites questions into whether average sex differences may be a result of learned gender socialization rather than solely due to genetic causes.

Similarly, we can also see a notable gender gap in general physical activity in children. Boys engage in an average of 11% more moderate-to-vigorous physical activity than girls and 44.7% more vigorous activity from 1st to 12th grade (Trost et al. 2002). Increased levels of activity, and especially vigorous activity, while growing up could lead to increased physical abilities like muscle mass and aerobic capacity as teens and adults.

Differences in strength may also be influenced by gendered social determinants. For example, one study found that 97% of the sex difference (variance) in strength between male and female swimmers was explained by muscle size, and sex differences in strength between male and female swimmers were smaller than that of non-athletes (Bishop, Cureton, and Collins 1987).

These differences in muscle size may be affected by differences in strength training. A meta-analysis found that adult male and female subjects gained similar amounts of muscle relative to body size when completing equal amounts of resistance training over time, with a slight favoring towards females (Roberts, Nuckols, and Krieger 2020). These studies suggest that if men and women were to exercise and train in equal ways, there may be a significant decrease in strength and muscle mass differences between men and women of the same size and a corresponding narrowing of the gender performance gap.

Yet, even when women exercise, they have historically avoided weight training. Gendered body norms and beauty standards encourage men to develop muscle mass but discourage women to do so. A late ‘90s study of gym-goers in Los Angeles, for example, showed the existence of a “glass ceiling” of strength that led many women to deliberately hold back from lifting weights to prevent gaining “too much” muscle (Dworkin 2001). Three-fourths of the women gym-goers expressed awareness of an “upper limit on the quest for seeking more muscular strength,” and

women reported consciously avoiding weightlifting or deliberately limiting it to avoid becoming "bigger", "buff", or "nonfeminine" (Dworkin 2001:337-338). One woman stopped lifting weights because she felt that she gained muscle too fast for a woman and didn't "want to look masculine," and a teenage athlete similarly said she kept her weights low and didn't do "too many" reps because she was "worried about getting bigger" (Dworkin 2001:339,343). Indeed, a systematic review by Vasudevan and Ford (2022) found that the biggest barriers to strength training for women were gender-based stigmas, negative comments and pressures from men as well as lack of knowledge, time, accessibility, and financial resources. If strength is determined by muscle mass, muscle mass is determined by strength training, and strength training is affected by gendered social norms, then it is possible that strength differences attributed to sex are partially or entirely due to gender instead.

Participation in sports is also affected by gender norms and roles. For instance, a study of 18-24 year-old Irish men and women identified barriers to female participation including expectations to stop playing sports at a certain age, less access to resources and opportunities, negative beliefs of women's capabilities, and sexualization, and social influence of friend groups with entirely positive effects among men but more mixed effects among women (Cummins and Byrne 2024). In elite equestrian sport, there are still social barriers preventing women from reaching the same levels as men such as men being more likely to be selected for elite teams and opportunities, differing levels of confidence, and more family expectations being put onto women preventing international competition chances needed to reach the top levels of the sport (Dashper 2012).

Even what we believe about the abilities of men and women can affect those actual abilities. Hively and El-Alayli (2014) found that in difficult tasks related to their sport, women college

athletes in both tennis and basketball performed equally as well as their male counterparts when they were told there was no gender difference, but when told there was a difference, the women then performed significantly worse than the men. This suggests that a sex segregated environment itself may communicate a supposed inferiority and contribute to worse performance.

Strength in Numbers

To some extent, athletic success on a population level may come down to a numbers game. Men's Olympic-winning performances in running events were found to have a moderate-to-high correlation (R^2 values of .68 to .95 based on event) with global population over time (Berry 2002). Berry concludes that "this distribution is constant through time — thus athletes are not getting better, nor are they better trained — there are just more of them" (Berry 2002:50). It makes sense that the more people there are to attempt something like running the 100m dash, the higher likelihood there is that someone does very well.

However, not every single person on the planet has an equal probability of winning Olympic gold. A young boy from a resource-rich family, for example, has a much better chance of becoming an elite athlete than one who comes from an impoverished family and grows up malnourished. A child in Canada or Switzerland is much more likely to grow up skiing or playing hockey than a child in Trinidad and Tobago. What is really being measured by Berry's performance model is not just total population, but the total population weighted by their social location and material advantages. If researchers measured the ice-skating abilities of adults from Ottawa versus Florida, for example, they would likely find a significant gap. There are many different "muscle gaps" that could be measured based on demographics.

A foundational and measurable factor that can operationalize many of these social factors is sports participation. The number of people actively training and competing in a sport represents a closer approximation of the given population's ability and potential to succeed in sports. In the United States, women's sports participation has grown rapidly compared to men's in recent history, and we have also seen women's top performances rise in a similar pattern.

Girls' high school sports participation in the US grew rapidly in '70s and early '80s following the implementation of Title IX, but it has changed very little since the early 2000's and is still notably lower than boy's participation (Stevenson 2007). At the same time, sex differences in world record running times stabilized after 1983 at about 10% for running, 8.9% for swimming, and 8.7% for cycling (Thibault et al. 2010). Thibault and colleagues suggest this plateau represents a physiological asymptote and conclude that "women will not run, jump, swim, or ride as fast as men" (Thibault et al. 2010:214). The above research outlining current gender differences in training, opportunities, and social influences suggests that this conclusion may be premature. Given that participation, opportunities, and recognition for women in sports is still below that of men, we must consider that these could be affecting such performance measures too. Of these potential social determinants, one of the most easily measurable at a large scale is participation.

Participation as a Meaningful Social Determinant

There remains significant gender inequality in girls' sports participation levels, so even a population with equal potential for skill will not reach those skill potentials if fewer girls are exercising, training, and playing. This is why it is so vital to investigate the social determinants of physical sex differences. A recent consensus statement from the American College of Sports Medicine reports that one important area needed in future research is "the impact and

identification of social determinants that influence the sex difference in performance including poor access to resources and athletic discouragement among females, and training based on male only studies." (Hunter et al. 2023:2350).

Participation in organized sports is a comprehensive and foundational way to operationalize many of the social factors affecting women and girls' physical development relative to men and boys. Youth school-based sports, specifically at the high school level, are important and understudied as this level represents an important part of the development pipeline to professional or elite sports and offers an entry path to newcomers. Additionally, education-based sports teams are regulated under Title IX of the Education Amendments of 1972 prohibits sex discrimination in federally-funded schools, which includes school-sponsored athletics programs (Francis 2016:2).

A stronger link between social determinants due to gender and measured sex differences in athletic performance would have wide-reaching ramifications in the current structure of sports. As seen at the beginning of this chapter, categorical sex differences that are biological in origin are the primary justification for segregating athletes by sex and restricting sex classifications of transgender athletes. These categories are justified due to the belief that males have an inherent physical advantage to females and thus female athletes cannot have fair competition against males. If sex differences are instead a result of social inequality, this could suggest a breakdown of causality in the sex differences-sex segregation relationship.

Sex segregation and resulting inequality may itself reinforce sex differences and would have significant policy implications regarding the future necessity of sex segregation as a requirement for fairness. If sex differences are to some extent a result of discrimination and inequality, then

efforts to promote fair competition should focus on breaking down binary conceptions of difference and supporting equal access and inclusion in sports.

The presence of social gendered impacts on athletic performance draws into question the accepted standard for sex differences and thus the premise for applying sex-based exclusionary policies in the name of fairness. Allowing partial or full sex integration would thus allow us to break down barriers and have more equal experiences, which would be more fair rather than less.

This study attempts to investigate whether participation rates in athletics are a meaningful social determinant of the gender gap in sports performance, specifically in high school track and field programs in the United States. Of the many possible social determinants of athletic performance outlined above, participation is one which has not been fully explored and can also be more easily measured at a large scale than the more cultural and interactional factors.

The primary research question of this study is as follows:

Does the number of athletes by gender participating in a state's high school track and field programs affect the gender gap in the state's championship-winning performances in the United States?

A handful of prior studies have investigated participation rates and performance by gender, though some did not directly analyze the two together. Hoffman and Wegelin (2009), for example, found that as women increasingly participate in 100-mile ultramarathons, average times of the top five women improved by 37 minutes per decade while men showed no significant improvement. While this study showed an increase in participation and an increase in performance, the statistical relationship between the two was not investigated. In addition, 100-

mile ultramarathons are quite extreme events that very few people of any gender attempt, so the extent to which these patterns translate to more popular activities is unknown.

Knechtle et al. (2020) measured participation rates and finishing times by sex in the Boston Marathon from 1972 to 2017, noting decreased performance gaps between men and women as well as a female participant ratio that increased from 5.72% of participants being female to 44.16% across the time span. In their conclusion, they suggest that "the decrease in performance difference between the sexes might be explained by the increase in female participation between 1972 and 2017. More women compete now, and also faster women are in the field" (Knechtle et al. 2020:8). These results suggest the potential for a relationship between sex gap and participation rate but do not directly analyze it. There is empirical evidence to support this. In the New York City Marathon, for example, the sex difference between first-place finishers decreased from 19.9% +- 7.7% in 1980-1985 to 12.6% +- 4.0% in 2006-2010 (Hunter and Stevens 2013:150). As for a relationship with participation rates, the ratio of men-to-women finishers was positively correlated ($r = 0.58$, $p < 0.05$) with sex difference in velocity (Hunter and Stevens 2013:152). Greater participation of women relative to men (a lower men-to-women ratio) was linked to greater equality in participation (a lower sex difference).

Nesburg et al. (2023:5) more directly examined the effect of participation ratios on running velocity of male and female runners at the Chicago and New York City Marathons, finding that "the ratio of the number of male to female finishers was correlated with the sex difference in velocity (percent) for both the NYC ($n = 4226$, $r = 0.56$, $r2 = 0.32$, $P < 0.001$) and CHI ($n = 2325$, $r = 0.53$, $r2 = 0.28$, $P < 0.001$) marathons. Thus, when there were fewer female relative to male runners within an age group, the sex difference in velocity was larger." Other findings are more

mixed. Knechtle et al. (2023) measured the male-to-female participant ratios and percent running speed difference for over 1 million Swiss running race records from the 5k to ultramarathon between 1999 and 2019. They found no significant correlation for 5k, 10k, and ultramarathon; a significant ($p<0.001$) negative relationship for the half marathon, and a significant ($p<0.05$) positive relationship for the marathon. Such a result warrants further study into the links between gender gaps in sports participation and top performances.

All of the relevant studies focus on adult runners and almost entirely at marathon or ultramarathon distances. Other settings and events warrant investigation as well. School-based sports are directly affected by Title IX regulations that mandate equal opportunity for boys and girls, thus providing a clearer look at any direct effects of the legislation on athletic performance differences. Youth track and field competitions at the high school level provide an opportunity to study the effects of participation on a range of events (including short- and long-distance events) during the developmental stage of potential high-performing athletes.

Hypotheses

The main hypotheses for this study are as follows:

H1: A lower male-to-female ratio of high school track and field participants will lead to a smaller gender gap in winning performances.

H2: A greater total number of participants in high school track and field leads to better top performances, with stronger effects among girls than boys.

METHODS

This study explores whether the gender gap in track and field performance can be explained to some extent by differences in participation. Participation seems to be one of the lowest hanging fruits in terms of measurable social determinants of athletic sex differences, yet it has not been studied enough at a large scale. A broad quantitative study of participation and performance trends among high school track and field athletes offers an important window into the measurable effects of gendered social patterns on physical development and would advance understanding of the causes of differences in athletic abilities between boys and girls. Specifically, this study examines whether the number of athletes by gender participating in a state's high school track and field programs affect the gender gap in the state's championship-winning performances in the United States.

To investigate this issue, the following analysis uses 41 years of state-level data across 17 states measuring boys' and girls' high school track and field participation and the winning times and distances from the corresponding state high school track and field championships. This section will describe the criteria and preparation of the data, descriptive statistics, and statistical analysis relating to the hypotheses.

Sampling and Inclusion Criteria

Track and field was chosen because it is one of the most popular sports among both boys and girls that also allows for comparison between the two (The National Federation of State High School Associations 2024). Apart from relays, track and field events are contested individually and consistently measured in the form of times or distances. This allows for a direct comparison of athletic performance between boys and girls, even though competitions are normally

segregated into gender categories. In a sport like basketball, another of the traditionally popular high school sports, athletic performance can only be measured relative to other teams included in the competition pool. This, combined with the fact that many leagues operate with different rules for boys' and girls' teams, means there is little to no way to accurately compare performance between genders.

Outdoor track and field was chosen over indoor track and field or cross country because it offers more variety in events than cross country and shows significantly higher historical participation than indoor track and field (The National Federation of State High School Associations 2023a).

The high school level was specifically chosen as it is more widely participated in and organized consistently nationwide compared to those of younger age groups. This level also has a more random and open selection of participants compared to the collegiate level in which participation is more determined by team roster and funding capacities, as few of those who want a spot on these teams will ultimately get one. Similarly, geographic distribution of talent in collegiate track and field is subject to selection bias, as athletes attend colleges across the country in search of the best environments to train and compete in. High schoolers, on the other hand, do not have much say in the state they grow up in and thus represent a more random distribution of potential talent across the country. High school track and field programs are also much more likely to accept all or most of the students who wish to join, making participation representative of interest and opportunity to participate relative to other sports and competition levels that are more selective and/or require greater economic resources to participate.

Five track and field events are examined: the 100-meter dash, 800-meter run, 1600-meter run, high jump, and pole vault. Hurdle and throwing events (shotput, discus, etc.) are not examined because there are different standards (hurdle heights and throwing weights) used for boys versus

girls, making these events unable to be compared between genders (The National Federation of State High School Associations 2023b).

The sample includes 17 states over a period of 41 years (1979-2019), chosen based on the public availability of their state track and field championship results. Years are notated as the year of the spring outdoor track season; for example, the 1979 season occurred during the spring months of the 1978-1979 academic year.

NFHS participation survey notes that collection methods changed starting with the 1979 survey, noting that accurate comparisons cannot be made between earlier data and the proceeding surveys. Thus, 1979 was chosen as the starting year for analysis. The year 2019 is the latest year used as this was the last complete season before the COVID-19 pandemic, which cancelled most 2020 seasons and strongly affected participation rates and performances in subsequent available years.

Data Sources

High school track and field participation data were obtained from the National Federation of State High School Associations (NFHS) High School Athletics Participation Survey. Data from the 2003 through 2019 spring seasons were downloaded in digital form directly from the NFHS website (https://members.nfhs.org/participation_statistics). Nondigitized data for the earlier years were downloaded in PDF form from the website's archive (https://www.nfhs.org/sports-resource-content/high-school-participation-survey-archive/). The NFHS survey is administered yearly to each state high school athletics association, where total numbers of participants on girls' and boys' teams for each offered sport are recorded as well as the number of schools offering each sport for girls and boys. Participation numbers only include interscholastic athletics, i.e., those that compete against other schools, not intramural or club. Thus, the data used for this study

represents the total number of girls and the total number of boys participating in outdoor track and field in each state, for each school year.

Historical performance data comes from records of past state track and field champions and their winning times/distances for each event, from state athletics associations websites (see appendix for specific links). Formats for this data included html sites, pdf and excel files, and online tables.

Variables

Participation is measured by the number of reported participants in girls' outdoor track and field and boys' outdoor track and field by state and year. Numbers are collected by the NFHS by surveying its member state athletics associations.

Gender gaps in participation were calculated as the percentage difference between the number of participants on boys' teams and the number of participants on girls' teams for each state-year observation.

Performance is measured using the winning times/distances published for each girl's and boy's state track and field championship per year. For states where competitions are divided into classes (e.g., 1A, 2A, 3A, etc.), each class's winning results were collected, and the best overall result per state-year-gender-event was used (lowest time for running races and greatest height for jumping events). Results from wheelchair divisions in the 800m and 1600m races were excluded as wheelchair racing at distances longer than 400m tends to show faster results than racing on foot, and the small number of wheelchair race results in this dataset would lead to inaccurate comparisons of ability (Loeppky 2021).

Relative performance differences by gender are calculated as the percentage difference between the top boys' and top girls' marks in each event for each state and year.

Sample and Preparation

The resulting dataset includes one observation per state, year, gender, and event. Data from competitions using comparable events (100 yards, 880 yards, 1 mile, 1500m) were converted to standard metric using factors from the U.S. Track & Field and Cross Country Coaches' Association website (Anon 2012). Participation data prior to 2003 in the form of scanned PDFs were digitized using Optical Character Recognition (OCR) software and then checked for accuracy by hand.

Significant outliers in performance data were confirmed or corrected, if necessary, using additional records. Data that is either impossible or with strong evidence suggesting it is incorrect were removed (See appendix for specifics).

While one metric (yards or meters) was used by each state for each year, performance data for Massachusetts listed their running events in forms such as "100y / 100m," leaving unclear when competition moved from English distances to metric. Based on email communication with the dataset manager, it likely depends on whether the championships occurred on high school or college tracks, as collegiate tracks switched to meters faster than high schools did (Martin 2024). The data source also included the site of the championships and shows a switch from high school to college tracks in 1982, leaving this the most likely year for a switch to metric compared to the other states included in this study. Thus, for this study, we assumed metric distances for 1982 and following seasons and used English distances for all earlier seasons.

In total, 4,296 state-year observations were collected for participation data (each observation including numbers for both boys and girls), and 24,464 state-year-gender-event-class observations were collected for performance. Selecting only the top performances among multiple classes and aligning both genders' observations for each state-year-event in the same row yielded the final combined dataset that includes 3,131 state-year-event observations. The data was cleaned and prepared using R, a statistical programming language.

Analytic Strategy

The most direct way participation may affect performance is that, statistically speaking, having more people train regularly and attempt competition could increase the likelihood of one of those competitors doing well. In a more sociological sense, the number of girls participating in high school track and field relative to boys in each school or region can both be representative of and help foster a culture that is more supportive of women and girls engaging and excelling in physical activities.

To test these ideas, this analysis uses fixed-effects panel regression models of high school state track and field data across 41 years and 17 states. Since the dataset includes observations from the same states over a period of years, we cannot assume that observations from the same state in different years are independent from each other. Using fixed-effects regression models helps account for this clustering.

The study first provides a descriptive overview of trends in the participation and performance data separately. It then analyzes the relationship between gendered participation and performance differences using ordinary least squares (OLS) regression with state fixed effects to account for time-invariant differences between states.

RESULTS

Participation

Table 1 shows participation measured as the percentage difference of boys to girls participating in outdoor track and field in each state. The percentage difference is calculated by subtracting the number of girls participating by the number of boys and dividing the result by the average of the two. This metric provides a standard measurement of the relative gender differences in performance between states.

Table 1: Average Gender Differences of Track and Field Participants by State

State	Average (% Diff.)	Min. (% Diff.)	Max. (% Diff.)	Std. Dev. (% Diff.)	Avg. Girls' Participation	Avg. Boys' Participation
Florida	21.270	1.340	44.957	11.154	10,132.073	12,625.244
Georgia	19.883	10.306	34.713	7.432	8,034.488	10,025.463
Illinois	25.037	18.001	34.576	5.237	17,570.244	23,441.220
Kansas	24.485	0.262	31.428	7.503	7,643.171	9,906.317
Maryland	21.666	10.718	44.560	8.818	4,253.268	5,400.024
Massachusetts	7.624	-7.797	25.116	7.723	10,111.463	10,936.268
Michigan	19.490	1.077	27.748	6.727	18,122.024	22,516.171
Nebraska	20.691	14.247	39.271	5.112	6,641.585	8,370.122
New York	10.733	-1.042	38.895	10.553	17,559.122	19,700.390
North Carolina	30.307	9.698	48.622	9.876	7,991.220	11,513.293
Oklahoma	14.347	-28.889	25.000	8.571	4,161.000	4,891.150

Oregon	30.954	18.612	50.000	9.925	6,771.902	10,045.683
Rhode Island	19.395	-8.573	52.533	16.981	1,194.829	1,480.951
Tennessee	12.154	-3.158	22.186	9.378	5,380.625	6,196.575
Washington	21.586	11.568	28.294	3.609	8,782.098	11,225.902
Wisconsin	16.296	-8.017	23.041	5.088	10,866.951	13,029.122
Wyoming	18.294	0.000	28.266	6.446	1,397.487	1,708.487

A positive percentage difference signifies more boys than girls, and a negative percentage difference signifies more girls than boys. Participation data is recorded for each state-year observation as the participation data represents all outdoor track and field participants and thus does not differentiate by event. The average gender gap in participation across all states was 19.37%. Every state averaged more boy participants than girls, and more than half never reported a season with more girls than boys. There was quite a bit of variation, with per-season differences ranging between a 28% difference in favor of girls to a 50% difference in favor of boys.

Table 2 shows the participation ratios of all measured states over the various time periods.

Table 2: Gender Gap in Track and Field Participation Over Time

Time Period	Average	Min.	Max.	Std. Dev.
[1979,1984]	26.149	0.000	52.533	13.427
(1984,1989]	25.797	-3.158	50.072	11.217
(1989,1994]	20.832	-0.442	40.250	8.303
(1994,1999]	14.161	-7.797	40.000	8.379

(1999,2004]	15.129	-8.017	34.576	8.710
(2004,2009]	18.145	-0.591	29.592	8.313
(2009,2014]	18.063	-28.889	32.348	9.846
(2014,2019]	18.002	0.468	30.847	7.731

Participation data represents track and field participants as a whole and is not differentiated by event. We can see from this that the average gender gap in participation decreases substantially from the early 1980's to the early 2000's, followed by a slight increase and then stabilization into the 2010's.

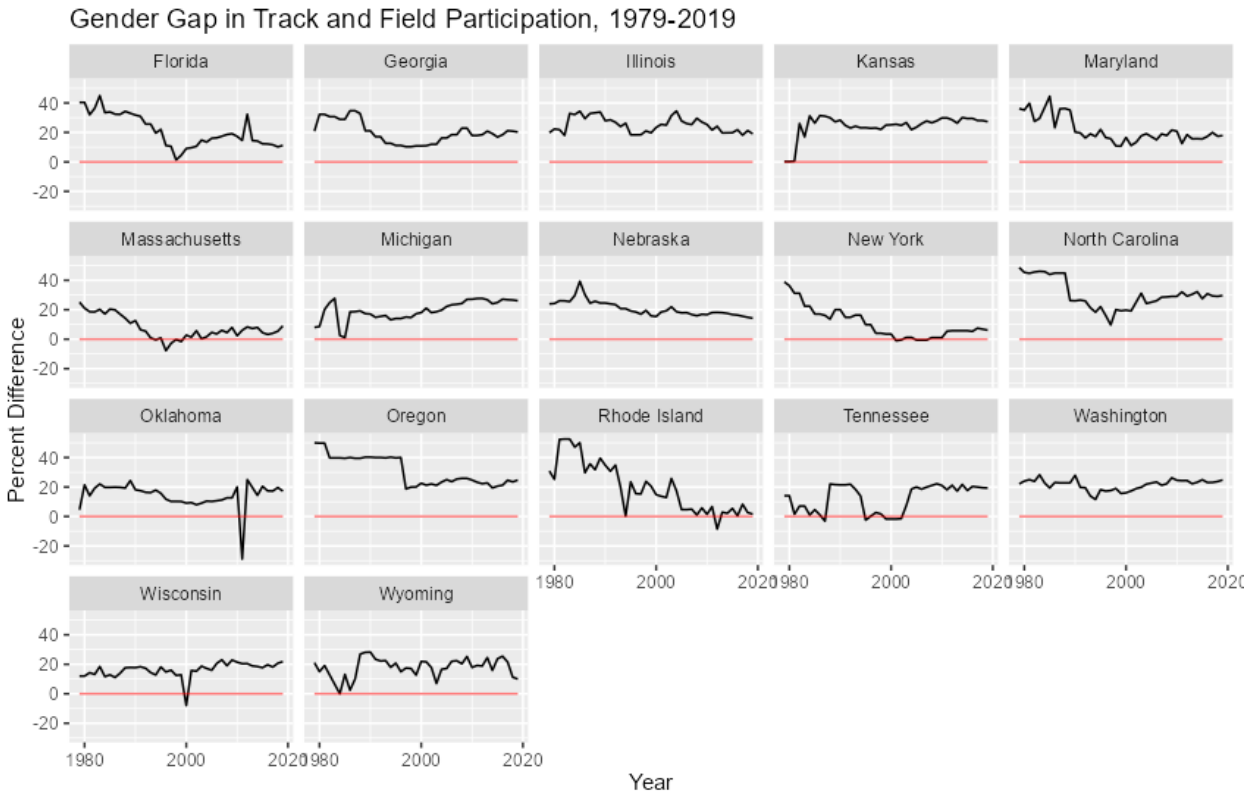

Figure 2: Boys-to-girls ratio in Track and Field Participation

Figure 2 shows the gender gap in participation in each state's outdoor track and field program over time. The gender gap is measured as the percentage difference of boys to girls in each state-year observation, with a reference line (shown in red) marking the value signifying an equal

number of boys and girls. As with Table 1, positive percentage differences signify more boys than girls participating in high school track and field in that state and year.

From Figure 2, we can see that, on a historical scale, there have been significantly more boys participating in high school track and field than girls have, and while trends in some states show increases in gender parity over time, others show more stable gender gaps. For example, New York shows a nearly 40% difference in boys' and girls' participation in 1979 but less than 10% by 2019. Washington, however, appears to hover at around a 20% difference the whole time.

Performance

Table 3 shows the average percentage differences in winning times between boys' and girls' competitions across all states and years in the study. For the running events, a lower time is the better performance, while for jumping events, higher values represent the better scores.

Table 3: Gender Gaps in Track and Field Performance by Event

Event	Average (% Diff.)	Min. (% Diff.)	Max. (% Diff.)	Std. Dev. (% Diff.)	Avg. Girls' Mark (sec, m)	Avg. Boys' Mark (sec, m)
100m	-11.679	-20.480	-1.240	2.189	12.057	10.725
800m	-16.224	-23.606	-8.520	2.256	134.042	113.906
1600m	-15.983	-22.440	-8.757	2.433	300.143	255.652
High Jump	18.834	7.895	30.065	3.451	1.700	2.053
Pole Vault	26.223	0.000	50.000	7.304	3.563	4.634

Average sex differences run from 11.7% in the 100m dash to 26.2% in the pole vault. Both the lowest and highest sex differences in state championship winning performances occurred in the pole vault, with one state championship (Massachusetts, 2003) seeing the boys' and girls'

champions win with the exact same mark (13’0”). There were no instances of a girls’ champion winning with a better mark than the boys’ champion of that same state and year.

Figure 3 below shows the winning performances across all included states by event and gender, from 1979 through 2019, with the solid line representing the year-to-year average for each gender.

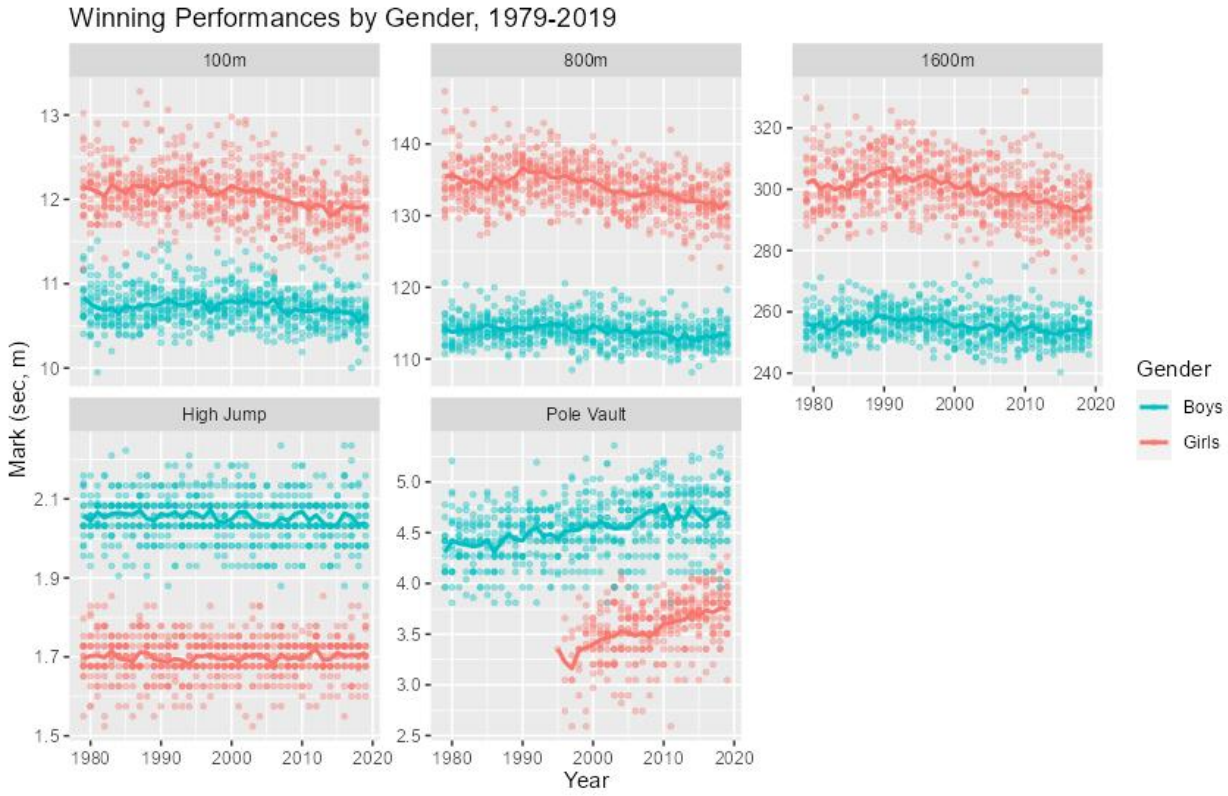

Figure 3: Winning performances over time

The girls’ pole vault is the only set of performances that do not include data starting from 1979, as high school track and field did not include girl’s pole vault competitions until between 1995 and 2002 for the states included in this data, with the average year being 1999.

For the running events, we can see a general trend of slight improvement over time, with greater improvement among girls’ scores compared to boys. In pole vault, there is steady improvement

among boys' scores, and for girls, there is a dramatic improvement in the earliest years of available data, with further improvement being consistent but smaller. Only in the high jump does there not appear to be much improvement at all over the years, with scores for boys decreasing slightly, if anything.

Analysis

The above section shows the trends of gender differences in high school track and field participation and performance over the previous 4 decades. However, we do not get any information on the relationship between them. There appear to be similarities in the broader trends of gendered participation and performance, but it does not tell us if there is any significant correlation at the state level between the two. In this section, I examine the relationship between participation and performance through the lens of gender.

Relative Effects: Participation gaps and performance gaps

Figure 4 shows the relationship between the gender gap in participation and the gender gap in performance for each event across the years, with each data point representing a single state-year observation.

Figure 4: Relative Performance and Participation (all states)

The running events and high jump show slight effects on performance gaps, each representing relationships showing larger gender gaps in participation correlating with larger gender gaps in performance. In contrast, the pole vault shows a larger gender gap in participation correlating with a slightly smaller gender gap in performance. Years are represented by the color of the dots, showing that participations gaps have shifted to be more consistently around the 20% range, while there was considerably higher variation in earlier years.

Table 4 shows the results of a fixed-effects OLS regression of a state's gender gap (percent difference) in track and field participation on the resulting gap (percent difference) in winning scores by event. For running events, negative performance gaps represent lower (better) times for boys than girls, whereas for jumping events, positive performance gaps represent better times for boys than girls, consistent with the descriptive statistics shown earlier in Table 3.

Table 4: Fixed Effects OLS regression of relative participation and performance

	100m	800m	1600m	High Jump	Pole Vault
Participation Gap (Pct. Diff.)	-0.034 *	-0.012	-0.023	0.009	-0.160
	(0.012)	(0.015)	(0.013)	(0.021)	(0.105)
N	693	693	693	692	360
R2	0.103	0.112	0.141	0.052	0.166

*** p < 0.001; ** p < 0.01; * p < 0.05.

Only one event, the 100m dash, significantly predicts that for each percentage point increase in participation gap, the gender gap in performance grows (becomes more negative) by 0.03 percentage points with slight significance ($p<0.05$). The other two running events as well as the high jump (a positive gap that becomes more positive) show similar yet smaller gap-narrowing margins but without statistical significance. The pole vault shows a one-point increase in participation gap predicting a 0.16 percentage point decrease in performance gap, a different relationship compared with the other four events, though this is not statistically significant.

This data suggests a small effect between relative gender gaps in participation and athletic performance at the state level, showing for four out of five events that larger participation gaps predict slightly larger performance gaps.

Absolute Effects: Total participation on performance by gender

The previous models measured the effects of relative gender gaps in participation on their corresponding gender gap in performance for each event. This frame of analysis only considers the effects of the difference between boys' and girls' participation in each state. It does not account for potential effects coming from the wide variation in total participants, largely due to the difference in those states' total populations. To examine the potential effects of total

participant levels on performance, I ran separate fixed-effects OLS regression models for both boys and girls on the effects of total participation levels on winning performances for each event.

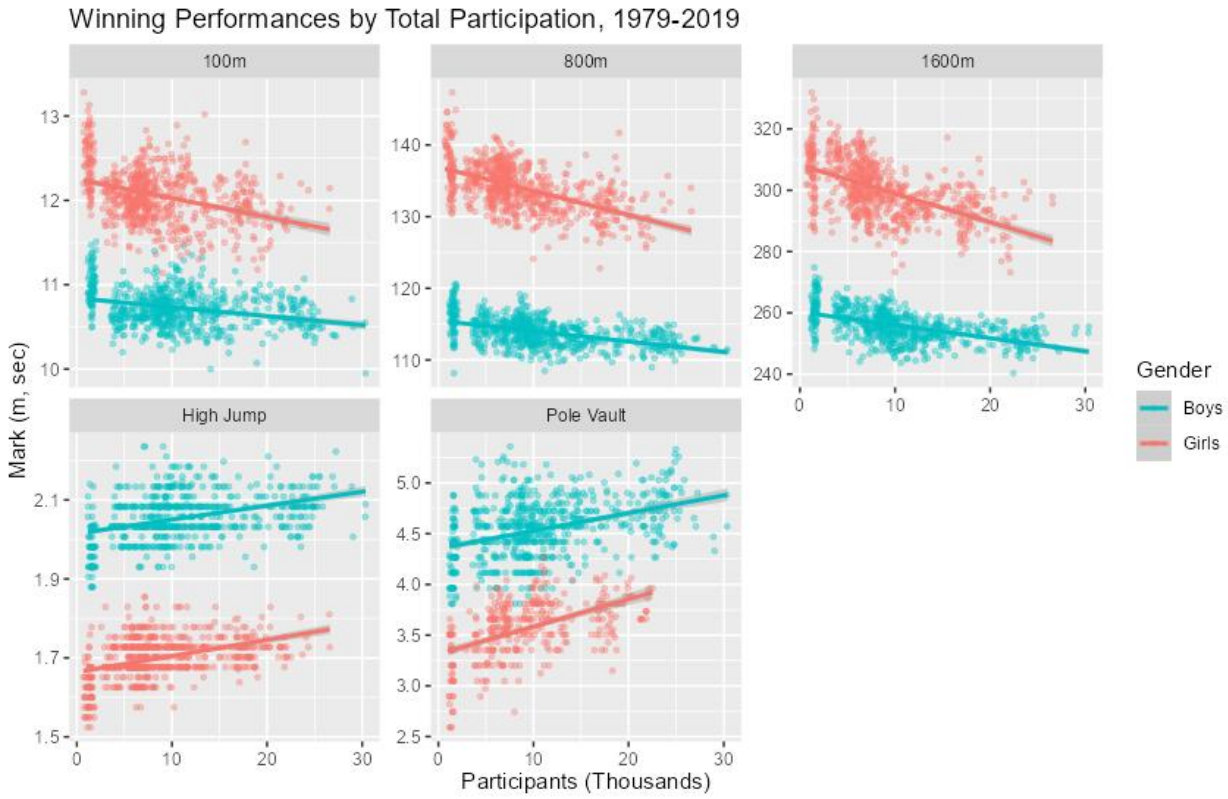

Figure 5: Total Participation on Performance by Gender

Figure 5 depicts the relationship between the number of boy and girl participants, in thousands, and their overall performance, for all state-year-gender observations. Trends across all five events show that increased participation is linked with better performances. We also see slightly decreased gender gaps in performance as participation increases. A meaningful gap still exists between boys' and girls' performance even when accounting for participation numbers, however, suggesting that increases in girls' participation to equal that of boys would decrease the gender gap in performance but would not erase it completely at current levels of boys' participation.

This implies that, while participation may be part of what determines performance, there are almost certainly other factors at play.

Table 5: Fixed effects OLS model (by state) of performance by total participants

	100m		800m		1600m	
Girls' Participation (Thousands)	-0.037 ***		-0.373 **		-0.928 ***	
	(0.007)		(0.110)		(0.213)	
Boys' Participation (Thousands)		-0.017 **		-0.131 **		-0.374 **
		(0.005)		(0.033)		(0.096)
N	693	693	693	693	693	693
R2	0.456	0.408	0.433	0.351	0.510	0.509

*** p < 0.001; ** p < 0.01; * p < 0.05.

	High Jump		Pole Vault	
Girls' Participation (Thousands)	0.001		0.063 **	
	(0.001)		(0.021)	
Boys' Participation (Thousands)		-0.000		0.032 **
		(0.001)		(0.009)
N	692	692	360	360
R2	0.365	0.367	0.511	0.566

*** p < 0.001; ** p < 0.01; * p < 0.05.

Table 5 shows the results of ten fixed-effects OLS models predicting the effects of absolute state participation numbers for boys and girls separately across all five events. Raw participation numbers for each gender are used in this model in contrast to relative participation differences between genders in order to capture effects stemming from having more total participants. In these models, all three running events show statistically significant relationships ($p<0.01$)

between the total number of participants and the winning performances. Notably, the effect for girls was more than double that of boys for all three events.

In the 100m dash, each thousand participants for girl's teams predicts a drop in 0.037 seconds, where for boy's teams this effect is 0.017 seconds. The 800m and 1600m races show improvements of 0.373 seconds and 0.928 seconds respectively for girls and 0.131 and 0.374 seconds for boys. All of these effects are statistically significant ($p<0.01$).

The pole vault models show a predicted 6.3cm of improvement in top score per thousand participants for the girls' competition ($p<0.01$) and 3.2cm per thousand participants for the boys' competition ($p<0.01$). For the high jump, the models predict no significant relationship between total participation and performance for neither boys nor girls.

These results suggest that there is a positive relationship between participation and top performance for the 100m, 800m, 1600m, and pole vault and that these relationships are stronger for girls than boys. We cannot conclude that there is such a relationship for the high jump.

Summary of Results

The above analysis did not find a consistent statistically significant relationship between year-to-year gender gaps in participation and corresponding gaps in performance. However, when looking at participation numbers as raw totals, for four out of five events, we find both significant relationships for boys and girls and that the relationship appears to be more than twice as strong for girls than boys.

This finding suggests that increasing numbers of track and field participants in a given state is positively related to better state championship-winning performances. This relationship is more than twice as pronounced for girls compared to boys. On a population level, this suggests that

greater increases in girls' high school track and field participation may work to decrease the gender gap in performance. At the same time, the models still show a notable gender gap in performance even when comparing equal numbers of boys and girls participating in track and field, indicating that while participation is likely a contributing factor to the gender gap in athletic performance, there are almost certainly other social or genetic factors at work.

DISCUSSION

This study aimed to investigate the effects of boys' and girls' participation in high school track and field on state championship winning performances. Average gender differences in top performances are commonly attributed solely to biological sex and as such are used to justify policies that separate male and female athletes in competition. To test whether gendered participation differences influence this performance gap, this study analyzed 41 years of state-level track and field participation surveys and state championship archives.

Two main hypotheses were examined: (1) that the relative gender gap in participation in a state positively affects that state's gender gap in performance and (2) that among all states, higher participation totals lead to better performances and that this relationship is stronger for girls than boys. Based on analyses using fixed-effects OLS regression models, I found weakly powered relationships for four out of five events between participation gaps and performance gaps in each state. Analyzing total participation numbers among boys and girls showed significant relationships between increased participation and better performances for four out of five events. This relationship is more than twice as strong for girls compared to boys for running events and pole vault. These findings suggest that overall increases in track and field participation are linked to stronger top performances, with increases in girls' participation having a stronger effect than for boys.

The presence of a relationship between overall track and field participation and top performances suggests that part of the reason average top performances for girls in high school track and field (and potentially in other sport competition settings) are lower than average top boys' performances may be due to the lower participation of girls compared to boys. Based on these

models' predictions, increasing girls' track and field participation at the state level to equal boys' participation would decrease the top performance gap, though likely not erase it entirely. Other factors most likely affect these performance differences as well. The extent to which these remaining factors are social or biological in origin is still unknown. Nevertheless, the results suggest gender difference in effects could be due to the historical and cultural context which has limited girls and women from fuller participation in sports at the same level as boys and men. This lower current level of population-wide achievement could mean there is greater potential improvement for girls compared to boys.

Implications

The findings support the assertion that current sex or gender gaps in sports performance may not be entirely attributable to genetic sex differences but also be shaped by socio-cultural factors as well. Specifically, the results predict that increased participation of girls to levels equal or greater to boys would result in a smaller, though still non-zero, gender gap in athletic performance. This suggests that at least part of the average differences between girls' and boys' athletic abilities are due to social inequalities rather than innate physiological differences.

At least until more research is done on the various social and historical effects of gender on the body and physical ability, we should not assume that differences between sexes in athletic abilities are based entirely on immutable genetic factors. Instead, we should consider how our abilities change and grow in relation to the structural and cultural environment we live in. Recall Williams, Haywood, and Painter (1996) study finding that boys' and girls' throwing ability differed with their dominant hand but not non-dominant, suggesting gender differences in throwing ability are likely products of differential experiences rather than innate potentials. The

structural and cultural environment that constructs ideas of what boys and girls, men and women, are and can become shapes the way we develop and exist in the world.

Policymakers should consider the social effects of gendered sports organization and broader culture when interpreting data on sex differences in athletic ability. Moves to further restrict sports participation by sex or gender may ultimately worsen inequality by entrenching gender stereotypes and reducing opportunities for men and women to train and compete at the same levels, while at the same time reinforcing a binary system that excludes any who do not conform.

Limitations

The findings of this study may be limited in some ways by the nature of the data collected. For one, trends at the state level may obscure specific effects of cities, schools, families, and individual interactions. Additionally, only looking at top performances cannot be seen as showing the average abilities of the general population. There is a considerable amount of overlap in abilities between men and women that are not reflected by looking at the performances of only the very best.

There are also many other social factors outside of participation rates that potentially contribute to gender gaps in performance. Just looking at the number of girls participating in track and field does not tell us about things like specific training methods and modalities and any structural or interpersonal bias and discrimination that may exist. It is possible, for example, that among high school track teams, certain members are given more attention, held to different standards, and offered different opportunities that may result in broader patterns of inequality in eventual achievement.

There may also be differences in childhood physical activity, sports participation, and additional training by gender. Broader patterns of gender inequality in these areas would lead athletes of otherwise equal potential to be starting their high school track careers at vastly different levels of ability.

This study does not account for the potential psychological effects stemming from self-perception, stereotype threat, external expectations, or sex segregated competition on performance. When girls are consistently exposed to messages of gender difference in natural ability, this may affect their performance in competition. Additionally, the structural effect of being segregated into separate competition may affect performance by having different levels of direct competition.

It is important to note the limitations of OLS regression models as an analytic strategy. First, they tend to be overly sensitive to outliers. Combined with the fact that only the top performers in the state are included, there may be certain levels of outlying data. Second, linear regressions assume linearity in the data. Trends influencing the data patterns are likely not perfectly linear in reality; however, this dataset does not appear to significantly deviate from generally linear trends.

Quantitative research, in general, strips data of its context by the nature of the method. Qualitative approaches such as interviewing runners, analyzing written records or commentary from events, or conducting ethnographic research on track and field teams would be able to capture more depth and see interpersonal dynamics at play. However, these do not allow for the same breadth of scale over geographic regions and decades to see the larger trends. At this stage of knowledge production with participation trends as a social determinant of performance differences, it is important to gather the broadest trends.

Future Research

Further studies should continue to investigate the impact of these social determinants on sex-attributed differences in athletic abilities, for example, whether average differences in muscle mass or cardiovascular endurance in transgender women after taking hormones compared to cisgender women are potentially caused not by a Y chromosome but as the result of growing up under the social forces of boyhood and all that it entails.

In addition, this study only looked at the performances of state championship winners. This may not accurately represent the average abilities of high school athletes, or high school students in general. A different study could try to investigate the physical abilities of an entire high school population with something like standardized physical education tests. This could be paired with surveys or tracked measurements of physical activity such as seen in Trost et al. (2002)'s study of physical activity in schoolchildren. This kind of investigation would require more resources to gather the data and would likely require a much smaller sample population because of this, but it could provide a more accurate look at the relationship between general physical activity levels and abilities in the general population.

Moreover, simple participation in one sport does not tell us about the real breadth and intensity of athletic training in a person's life. A more in-depth study could survey or otherwise track a smaller group of athletes' full history of physical activity, sports participation, and other athletic training as well as their current level of training activities to better address how the local environments shape athletic outcomes. Specific cultural beliefs and practices around girls in sports should be investigated as well and would be augmented by qualitative studies that understand how these beliefs and practices are interpreted by both boys and girls, especially as

differences in opportunity, encouragement, and support for girls may differ from that for boys and reinforce differences in physical activity discussed above.

Further studies should also investigate what explains the variation in trends in participation and performance observed among different states. There were noticeable differences in the trends over time of the participation gender gaps among states. Some, like New York and Rhode Island, showed consistent decrease in participation differences reaching near-equal levels of participation by the early 2000s. Others, like Michigan, Wisconsin, and Washington, show flat to even slightly increasing gender gaps in participation over time. Florida, North Carolina, and Massachusetts all show somewhat of a "V" shape in trends, with the participation gap decreasing until the mid-1990's or so and then beginning to increase after. More investigation is needed to better understand these differences, whether they are due to specific regional trends, policy changes, cultural or political shifts, or other reasons entirely.

Lastly, there are divergences in the relationships between participation and performance that warrant further investigation. For example, while most states in the study showed a generally positive relationship between total participation levels and performance across all events for both genders, states such as Washington and Wyoming showed a slightly negative relationship. There could be specific contextual factors or unknown variables that lead to these differences.

Which Differences Matter?

In the broader landscape of sports, gender, politics, and the body, the specific differences focused on in this study represent only one perspective. As Kane (1995:200) puts it, there is not just one but "many muscle gaps" that can be measured among humans. Human bodies vary in many ways, including height, weight, flexibility, bone density, joint structure, muscle mass, and so

much more. Between which groups of people we measure differences and to what significance we then attribute is much more of a social construction than we often like to admit; consider that the average Estonian is 7 inches taller than the average Guatemalan (Anon 2024a). Does this mean Guatemalan basketball players should not be allowed to compete at the highest levels of international competition? If this were the case, Central American teams might win more "short league" championships, but those wins would be sidelined as less important. It would also disadvantage shorter-than-average Northern Europeans while preventing taller-than-average Central Americans who may excel at the highest level of competition.

Every decision to draw categorical boundaries between populations is based on a particular cultural context and always comes with political and social ramifications. Enshrining such group-based differences into institutions like sports exaggerates this difference and essentializes specific traits as determining overall ability. In the same way that height is not the only predictor of basketball skill, neither do variations in muscle mass and cardiovascular capacity universally determine athletic skill more generally. When considering the organization of gender in sports, we should consider not just quantified differences but the kind of world we want to create.

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APPENDIX

Data Sources

Participation data sources: https://members.nfhs.org/participation_statistics, https://www.nfhs.org/sports-resource-content/high-school-participation-survey-archive/

Performance data sources: https://www.ahsaa.com, https://www.gatfxcca.org, https://www.ihsa.org/, https://khsaa.org/, https://www.mpssaa.org/, https://mstca.org/, https://my.mhsaa.com/, https://nsaahome.org/, https://nysphsaa.org/, https://www.nchsaa.org, http://www.ohstrack.com, https://www.osaa.org, https://tssaasports.com, https://www.wiaawi.org, https://www.whsaa.org, https://sites.google.com/view/rihstrackandfieldhistory, https://washingtontrack.com

Missing Data

Out of the possible 697 (41 years x 17 states) observations for each event, 4 are not present overall (2 originally missing, 2 removed) for the following reasons:

Originally Missing Participation Data

- Wyoming, Boys, 1982: Data blank in original survey
- Wyoming, Boys, 1983: Data blank in original survey

Originally Missing Performance Data

- Massachusetts, Boys, 1985, High Jump: Data missing on web table

Removed Cases Because of Likely Errors

1. The track and field participation data for both boys and girls for Oklahoma in 2013 were listed as 0. Given that there are performance records from Oklahoma's 2013 state championship, this is almost certainly not correct, so this data was excluded.

2. There is a significant spike in the participant ratio seen with Tennessee in 2008. Investigation into the data source shows that the girls' participation hovers consistently in the 5,500-5,700 range in the surrounding years, but in 2008 drops to 2,915. This happens to be the exact same value as the nearby number for Tennessee girls' tennis participation, which suggests this outlying value may be an error in the data reporting. Upon contacting the NFHS with this information, the Assistant Director of Publications and Communications confirmed via email that this value is "very likely incorrect" but that they do not have the correct number at this time (Boone 2025).
3. 1990 Georgia Girl's 1A 800m has a posted time of 58.9. This is far too fast for an 800m (the all-time world record for this event is 1:40.91, per https://worldathletics.org/records/all-time-toplists/middlelong/800-metres/outdoor/men/senior) and is also the same as the winning 400m time (won by the same athlete), which makes it highly unlikely to be the correct result. I was unable to find the correct time with another source. Other classes had valid performances, so the best of those times is used for the Georgia Girls 1990 800m observation.