VIDEO TRANSCRIPT

Sex, Genetics & Athletics

Link to video.

Slide 1

Athletics are often divided into men's and women's categories to provide fair competition, but efforts to define who qualifies to compete in the women's events have been fraught with controversy. In this lesson, we will use the history of sex testing in elite female athletics to help us explore the complexity of human sex variation.

Slide 2

Before we begin, I want you to imagine you are an elite female athlete competing in national and world championships.

You identify as a woman and haven't considered other possibilities. One of your competitors questions whether you are "truly biologically female" and anonymously asks officials to investigate your sex.

The group that makes the rules about who can compete is deciding whether or not you qualify as a female and should be able to participate.

How do you think you would respond to this type of investigation?

What do you think the investigation might involve?

What could the other athlete be thinking about?

You may want to pause here for a few moments to think of your responses before continuing with the presentation.

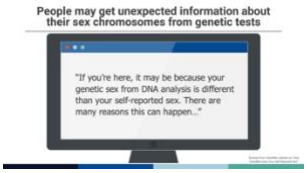
Slide 3

This might seem like an invented scenario, but it is based on the real-life experience of world champion middle-distance runner Caster Semenya.

Caster Semenya is a world champion runner who experienced her competitors questioning if she was a "real woman," in part because of her running victories, her rapid improvement in performance, and her muscular appearance. The group referenced in the slide represents the International Association of Athletics Federations (IAAF) (now called World Athletics) and the International Olympic Committee (IOC), two organizations that make decisions about who is allowed to participate in sporting events, set policies that apply to all athletes and are often seen as models for other organizations. Responses to the questions on the previous slide often vary. Many people have never considered such a question. Others may have had their own sex or gender identity questioned in some way, while others are firm in their belief that designating people as male or female is a simple task.

This may be a sensitive topic for people to talk about and we recommend taking some time to set ground rules for respectful dialogue before discussing this topic in a group.

Slide 4



Learning unexpected information about one's biological sex is not just the purview of elite athletics – direct-to-consumer (DTC) genetic testing can also reveal previously unknown differences of sex development.

Many people take genetic tests to get a sense of ancestry, health risks or carrier status. Some individuals are surprised when their test results reveal that they have a different complement of sex chromosomes than expected. It is common enough for people to receive results that don't align with their self-reported sex that DTC test providers have created a landing page for questions. Overall, learning about our DNA means we are learning a lot about the breadth of variation in human populations.

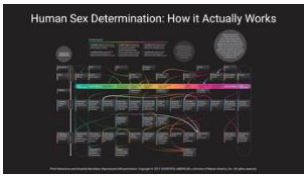
Slide 5

To understand this situation, we need to understand how sex is determined. For many, it's a lot more complicated than you've been taught.

Slide 6

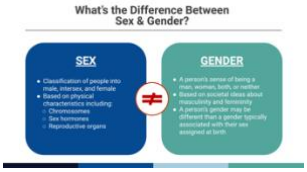
What most of us learn in biology class is that in humans, sex is determined by the X and Y chromosomes with females having XX chromosomes and males having XY. A person with XX chromosomes will develop ovaries, a uterus and a vagina; estrogen will be the dominant sex hormone, and at puberty breasts will develop. A person with XY chromosomes will develop a penis and testes, testosterone will be the dominant sex hormone, and facial hair will begin to appear at puberty. It all seems very straightforward.

Slide 7



The reality of human sex determination is complicated, as is illustrated in this infographic from Scientific American. Without going into the details, the far-right column that has a dotted line circling it is the typical XY male as described in the previous slide. The column second from the left is the typical XX female. Everything in between illustrates differences in sex development (DSDs) that are often left out of the discussion. People whose sexual development follows one of these other pathways are called intersex. Intersex people account for approximately 1.7% of the population, making intersex variations about as common as having red hair or green eyes.

Slide 8



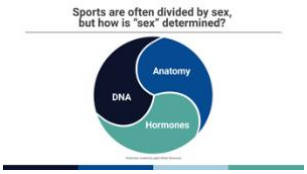
The terms "sex" and "gender" are often confused, but these two words have separate and distinct meanings and are not interchangeable. "Sex" refers to the classification of people into "male", "intersex", and "female" based on physical characteristics, including chromosomes, sex hormones, and reproductive organs. "Gender" refers to behavioral, social and other factors pertaining to the meaning or role of being a "man", "woman", both, or neither. A person's gender identity may be different than the one typically associated with their sex assigned at birth.

In this lesson, the focus is on sex as it relates to athletics – specifically the division of athletics into men's and women's events and the history of sex testing of athletes in the women's events. This is not a lesson on transgender athletes.

A quick note on language: You may notice that while sports are divided by sex (male vs. female), the categories are named using gendered terms (men's vs. women's events).

This is an example of the confusion that is caused by using these terms interchangeably.

Slide 9



In an effort to provide fair competition and increased athletic opportunities for women, sports are often divided into separate categories by sex. Elite sports, such as the Olympics or "world championship" races are overseen by international organizations that set rules and guidelines for athletes and include The International Olympic Committee (IOC) and World Athletics (formerly the International Association of Athletics Federations (IAAF)). Since the mid-20th century, these organizations have used various methods for verifying the sex of athletes competing in women's events, including examining athletes' a) anatomy, b) DNA, and c) hormones.

Slide 10

Since women were first allowed to compete in track and field events in the 1928 Olympic Games, there have been voices suspicious of "un-feminine" levels of performance. After the 1936 Berlin games, the president of the US Olympic Committee, Avery Brundage, was worried about the threat of "hermaphrodite" athletes compromising the "integrity" of women's sports, and "demanded examination for sex ambiguities in all women competitors." (The word "hermaphrodite", used here because it is a direct quote, is now considered to be pejorative. "Intersex" is the accepted word to refer to individuals who do not easily fit into the male/female sex binary.)

The next three Olympic Games were canceled due to World War II. By the time they returned in 1946, international sports organizations had begun sex testing competitors in women's events. The slides that follow provide an overview

of the 70-year history of "sex/gender tests" for female athletes in international sporting events. (Historically, these were referred to as "gender tests" even though they were actually verifying the athletes' sex.)

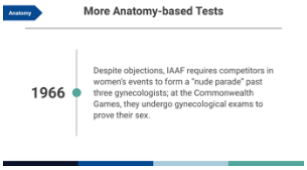
Slide 11

Let's look at the various ways sports governing bodies have tried to define sex, starting with anatomy.

Slide 12

Beginning in 1944, the IAAF required competitors in the women's events to submit a medical certificate from their home country verifying their sex. (The IOC did the same in the first post-war Olympic Games in 1946.)

Slide 13

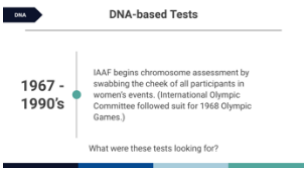


Suspicions about certain countries falsifying their tests resulted in the 1966 decision from the IAAF to examine the genitals of athletes in women's events. In some cases, the athletes were required to take part in a "nude parade," in which they walked in front of a panel of doctors at international competitions. "Nude parades" caused a controversy and were abandoned by the IOC in favor of what they considered to be a more scientific effort to assess sex.

Slide 14

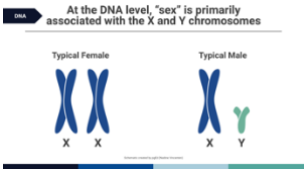
Thus, began the era of DNA-based sex tests in women's athletics.

Slide 15



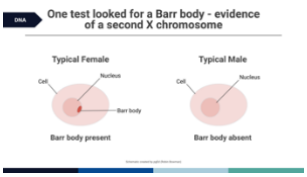
In 1967, the IOC and IAAF switched to lab tests to check the sex chromosomes. These tests were used until the 1990s. What were these tests looking for?

Slide 16



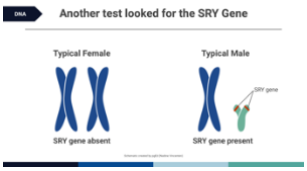
The challenges of sex testing in sports can be illuminated by examining the biology of sex. At a genetic level, "sex" in humans – the physical and reproductive differences between males and females – is primarily correlated with the sex chromosomes. In typical females, cells contain two X chromosomes, while in typical males, there is one X and one Y chromosome. The X and Y chromosomes share a small number of genes. However, the Y is about one-third the size of the X and has less than one-tenth the number of genes.

Slide 17



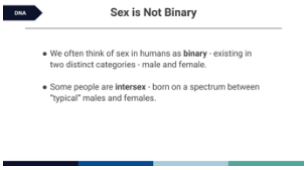
One DNA-based test looked for the presence of a Barr body – an inactivated X chromosome – in the athletes' cells. In individuals with two X chromosomes, one of the X chromosomes in each cell is inactivated and condensed. The inactivated X chromosome appears as a dark spot, called a Barr body, near the edge of the nuclear membrane when viewed under a microscope. In this era, the presence of a Barr body was generally considered to confirm female sex – and allowed the athlete to participate in the women's events.

Slide 18



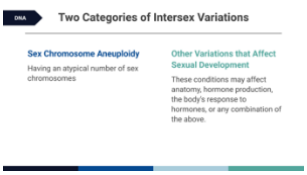
Another DNA-based test looked for the presence of the SRY gene. Many genes, on the sex chromosomes as well as the other 22 pairs, play important roles in forming the testes and the ovaries (the reproductive organs, or gonads, where sperm and egg cells mature). Some of these genes, such as the SRY gene typically found on the Y chromosome, actively suppress the development of the ovaries and promote the development of the testes. Other genes do the opposite and encourage the growth of ovaries and suppress the development of testes. From 1967-1990's, any athlete having an SRY gene would be deemed male and ineligible to compete in women's competitions.

Slide 19



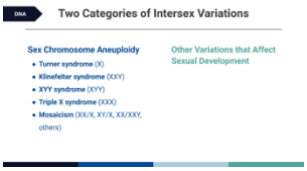
Although we often think of sex in humans as binary – existing in two distinct and mutually-exclusive categories of male and female – this over-generalization does not accurately represent the genetic and biological complexity of sex determination. While typical males and females have physical and chromosomal differences, there is a small but significant portion of the population whose sex does not conform to the commonly understood categories. These individuals with differences in sexual development (DSDs) are referred to as "intersex."

Slide 20



Broadly, there are two categories of biological bases for intersex traits: (1) having an atypical number of sex chromosomes (sex chromosome aneuploidy), or (2) having a typical combination of sex chromosomes but possessing other genetic variants that affect how the reproductive system develops. We will explore examples of each on the following slides.

Slide 21



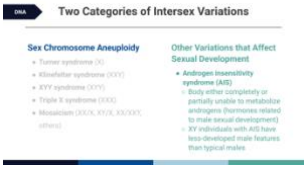
Intersex traits caused by having an atypical number of sex chromosomes (sex chromosome aneuploidy) are fairly common. Examples include Turner syndrome (X), Klinefelter syndrome (XXY), XYY syndrome (XYY) and triple X syndrome (XXX). Individuals with sex chromosome aneuploidy have a wide range of physical, cognitive, and reproductive characteristics.

It is also possible for certain groups of cells in the developing fetus to lose one of the sex chromosomes, resulting in a "mosaic" individual who has some cells that contain XY (or XX) while others contain only a single X. Other mosaic individuals may have some cells with XX chromosomes and others with XXY. An athlete with XX/XXY mosaicism may develop as a typical female and have no idea they have a Y chromosome until they fail a sex verification test based on the presence of the SRY gene.

Slide 22

Ewa Kłobukowska, a Polish Olympic sprinter, has an intersex variation called "genetic mosaicism" in which some cells contain XX chromosomes and others contain XXY. In 1967, she was the first athlete to fail the genetic "gender verification tests" of athletics authorities, due to her extra chromosome, and was stripped of her medals and world records.

Slide 23



Another group of intersex individuals have typical combinations of sex chromosomes (XX or XY) but possess genetic variants that affect how the reproductive system develops. Individuals with these genetic variations often have gonads that are nonfunctional (called "streak gonads") or, in very rare cases, have both testicular and ovarian tissues

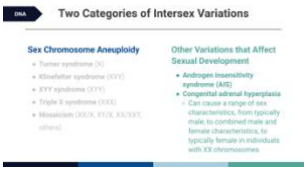
(an "ovotestis"). External sex organs and secondary sexual features may take a range of forms - typical for what might be expected from their sex chromosomes, opposite of what might be expected, or ambiguous.

Of these intersex variations, Androgen Insensitivity Syndrome (AIS) is one of the most common. Androgens are hormones that promote male sexual development and masculinization of the body. Testosterone is an example of an androgen. In AIS, genetic variation in the androgen receptor gene decreases the body's ability to respond to androgens. Because of this decreased ability to respond to androgens, AIS causes individuals with XY chromosomes to have less-developed male features than typical males. This can occur even if they have high levels of androgens circulating in their bloodstream. In cases of complete AIS (CAIS), a person with XY chromosomes would have sexual features of a typical female, but internal testes in place of ovaries.

Slide 24

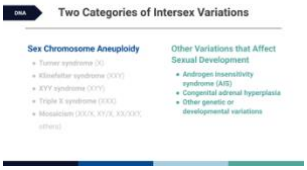
In 1986, Spanish hurdler María José Martínez-Patiño was disqualified after a sex verification test showed she had XY chromosomes. She protested the disqualification based on having androgen insensitivity syndrome (AIS) and was eventually reinstated. She is now a professor of sports science and has written extensively on AIS and sex testing in sports.

Slide 25



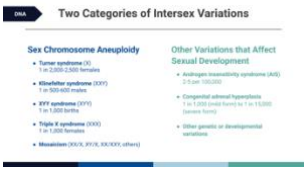
Congenital adrenal hyperplasia (CAH) is an intersex variation in which production of androgens is increased. Elevated androgen levels can lead to a range of typically male sexual features in XX individuals. (While CAH can also affect individuals with XY chromosomes, it does not result in intersex traits.)

Slide 26



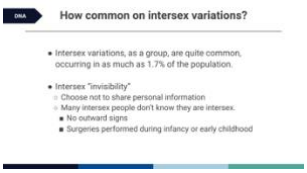
There are many other variations that may affect sexual development, but we are focusing here on those that are relevant to women in athletics. For that reason, we are not discussing differences of sex development that affect individuals who would likely be identified as male.

Slide 27



Estimates of the prevalence of individual DSDs vary, and many intersex people may never learn that they are intersex.

Slide 28

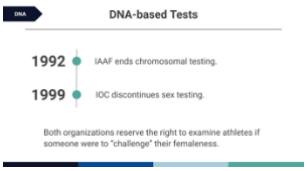


While each individual DSD is considered rare, being intersex is fairly common. Intersex traits occur in up to 1.7% of the population (with estimates varying due to differing definitions of what counts as intersex).

However, intersex variations are often considered "invisible." Many intersex people choose not to share this personal information about themselves. Others are not aware they are intersex, either because they never had outward signs or, because of the common practice of performing surgeries during infancy or early childhood to make intersex bodies conform to the male/female binary. These surgeries are often medically unnecessary and involve parents and/or doctors

deciding about whether to make their child appear male or female. Their decision does not always align with the child's eventual sense of self, and sometimes the child is never told about the surgery or is lied to about the reason for it. This "invisibility" can lead us to think that being intersex is very rare when, in fact, most of us likely know at least one person who is intersex.

Slide 29

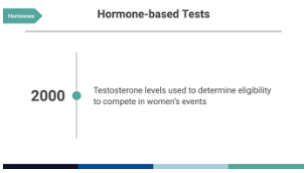


Both the IAAF and the IOC ended compulsory chromosomal sex testing of all competitors in women's events in the 1990s. However, they reserved the right to examine athletes if someone were to "challenge" their femaleness.

Slide 30

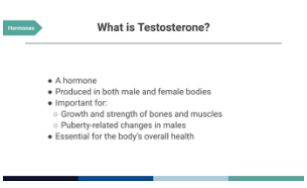
Testing hormone levels replaced chromosomal testing as a way to determine eligibility to participate in women's events.

Slide 31



Starting in 2000, athletes' testosterone levels were used to determine eligibility. Like earlier methods of sex testing, this too would be controversial.

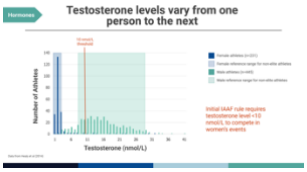
Slide 32



Testosterone is a hormone produced in both male and female bodies. Testosterone has many effects on the body, including promoting the growth and strength of bones and muscles and causing many of the puberty-related changes in males. While testosterone is the primary sex hormone in males and estrogen is the primary one in females, both

hormones are produced in all humans, with levels varying from one individual to the next. Both testosterone and estrogen are required for the body's overall function in both male and female bodies, and imbalances in the levels of these hormones can affect health.

Slide 33



Testosterone levels vary from one person to the next. This image shows a comparison of testosterone levels between male and female elite athletes. The areas in the shaded boxes show the reference ranges considered "normal" for non-elite athletes (<2.7 nanomoles per liter (nmol/L) for females, 8.4-28.7nmol/L for males). While there is a difference in the distribution of testosterone levels between males and females, notice there is significant overlap of the ranges, with both males and females ranging from nearly 0 to over 30 nmol/L.

When hormone testing began to be used to determine eligibility, the IAAF set an initial threshold of 10 nmol/L for competitors in women's competitions. Those with testosterone levels above the cutoff would have to have surgery or take medication to lower and maintain their testosterone level below the 10 nmol/L threshold to compete.

Slide 34

In 2008, Caster Semenya, a South African middle-distance runner specializing in the 400m, 800m and 1500m events, emerged as an international talent. In 2009, the IAAF requested that Semenya be subjected to sex testing due to suspicions raised by her performance and, in particular, her rapid improvement in performance. This led to her disqualification from competition due to her natural testosterone levels being higher than the 10 nmol/L

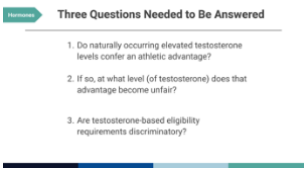
threshold. Feeling she had no other choice, Semenya began taking medication to lower her testosterone levels so she could compete.

In 2014, Dutee Chand, a 100m sprinting champion from India, was also disqualified due to hyperandrogenism, or naturally elevated testosterone. She refused to undergo treatment for her hyperandrogenism, arguing that it was unfair that she was required to undergo medically unnecessary treatments to continue to compete.

Slide 35

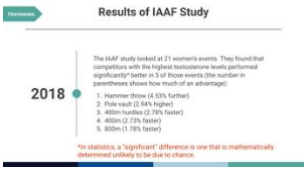
In 2014, after being dropped from India's national team, Chand sued the IAAF over the testosterone rule. This was the beginning of a long legal battle over hormone-based sex testing. Chand's lawsuit resulted in the court ruling that the IAAF must suspend the regulation until providing scientific evidence to support the legitimacy of this 10 nmol/L threshold for athletes to compete in the women's division.

Slide 36



At the heart of the lawsuit were two main questions: 1) Do naturally occurring elevated testosterone levels confer an athletic advantage? 2) If so, at what level (of testosterone) does that advantage become unfair? The court gave the IAAF two years to provide scientific evidence to support their claim.

Slide 37



The IAAF hired scientists to study the testosterone levels of elite track-and-field athletes. Of the 21 events studied, researchers found that athletes with the highest levels of testosterone performed significantly better than those with

the lowest levels in five events – the 400m, 400m hurdles, 800m, hammer throw and pole vault.

Slide 38

Imagine you are a member of the IAAF board, and you have just been given the results of the study of the relationship between testosterone levels and performance.

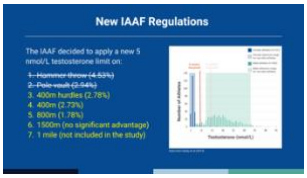
This study looked at the testosterone levels of competitors in the IAAF World Championships in 2011 and 2013. Athletes were divided into three groups (tertiles), based on testosterone levels. Then, the performances were compared between athletes in the highest and lowest tertiles for each event. The margin of advantage was calculated by comparing the averages of these two groups.

The five events listed are the only events for which a statistically significant correlation was found between high testosterone levels and increased performance in female athletes (the number in parentheses shows how much of an advantage).

For which, if any, of these five events would you set a testosterone threshold?

Pause here and take a moment to think about it before continuing.

Slide 39



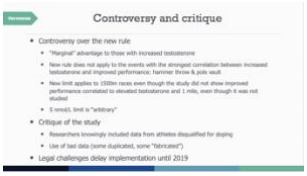
In 2018, after completing their study, the IAAF decided to reinstate their testosterone regulations, but with a narrower focus. Under the new regulations, testosterone limits only apply to athletes with DSDs participating in certain women's events – international races between 400m and 1 mile. This includes the 1500m race, which showed no statistically

significant advantage to those with elevated testosterone, as well as the 1-mile race, which was not included in the study. The rules do not apply to hammer throw or pole vault.

They also lowered the testosterone limit from 10 nmol/L to 5 nmol/L.

In case you were wondering, the study also looked at male athletes in the same World Championship events. No significant difference was found between athletes in the highest and lowest testosterone tertiles for any event.

Slide 40



The new testosterone rule was very controversial and strongly critiqued. Critics say that the methods used in the IAAF-commissioned study are flawed. The performance advantage provided by increased testosterone levels that was observed in the IAAF's study, falls within the range deemed "marginal" by the Court of Arbitration for Sport (CAS) and does not come close to the performance difference between typical male and female athletes. Additionally, the new rule only applies to middle-distance races – including events for which there is no data to support the regulation – and does not apply to hammer throw and pole vault, for which the performance advantages correlated with high testosterone were shown to be the highest in the study. This has drawn additional criticisms for the "arbitrary" nature of the rule, particularly, the new 5 nmol/L threshold.

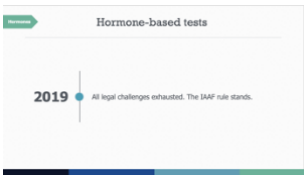
The study has also been critiqued for including data from athletes who had been disqualified for doping, and for using duplicated or "fabricated" data (e.g., race time data points

for which no match was found in the official race times from the events that those data supposedly came from).

Legal challenges brought by Caster Semenya delayed implementation of the rule until 2019.

The IAAF asserts, "...that the DSD Regulations are a necessary, reasonable and proportionate means of protecting fair and meaningful competition in elite female athletics..."

Slide 41



In 2019, all legal challenges were exhausted, and the IAAF ruling took effect.

Slide 42

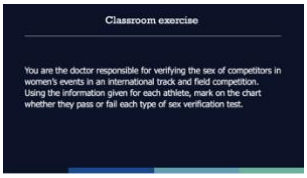
What do the new IAAF regulations mean for Chand and Semenya? The new IAAF rules for athletes with DSDs apply only to athletes competing in international races between 400m and 1 mile. Since Dutee Chand competes in the 100m, she is free to compete.

Caster Semenya, as an 800m racer, is subject to the regulations. Competitors in these events have several options: 1) lower and maintain their testosterone levels below the threshold for at least 6 months via medication or surgery to remove testicular tissue that may elevate testosterone; 2) participate in an event not covered by the regulation; 3) enter non-international competitions not governed by this rule; 4) compete in the men's division; or 5)

possibly compete in another, distinct, third division that does not yet exist.

Semenya, in an article in the Los Angeles Times, responded to the ruling saying, "I am a woman and I am a world-class athlete. The IAAF will not drug me or stop me from being who I am."

Slide 43



There is an activity that goes along with this lesson that challenges students to step into the role of a doctor responsible for verifying the sex of the competitors in an international track and field competition. We encourage you to complete this activity.

Slide 44

After completing the activity, take some time to reflect on the experience and consider the questions posed here. When used in the classroom, debriefing is a critical part of the activity to give students an opportunity to discuss how they made their decisions, how categorizing these athletes made them feel, and to process the difficulty of the exercise and limitations of a binary system of sex classification.

Slide 45

Many questions remain about the current and future practice of sex testing in athletics. Critics question the singular focus being placed on testosterone levels, and not other physical characteristics such as height, lean body mass or lung capacity, which also confer performance advantage. Others point out that sex verification in sports has always only targeted athletes in the women's division, not those in the men's. Many also note the seeming contradiction in having an upper testosterone-level threshold for women's events, but neither an upper nor lower threshold for men's events.

Will testosterone levels remain the metric by which eligibility is decided? Might there be another method by which athletes could be sorted to offer fair competition?

Slide 46

While this lesson highlights the issues of elite athletes, the broader concepts apply to everyone, and can be used to facilitate discussions about fairness and destigmatize differences in sexual development. This slide lists resources for further inquiry and support, including a podcast episode from the Radiolab Presents: Gonads series, called “Dutee”, the NIH webpage for Numeric Sex Chromosome Variations, and the websites for two intersex organizations, AXYS and InterAct.