Biological perspectives on transgender athletes in sport

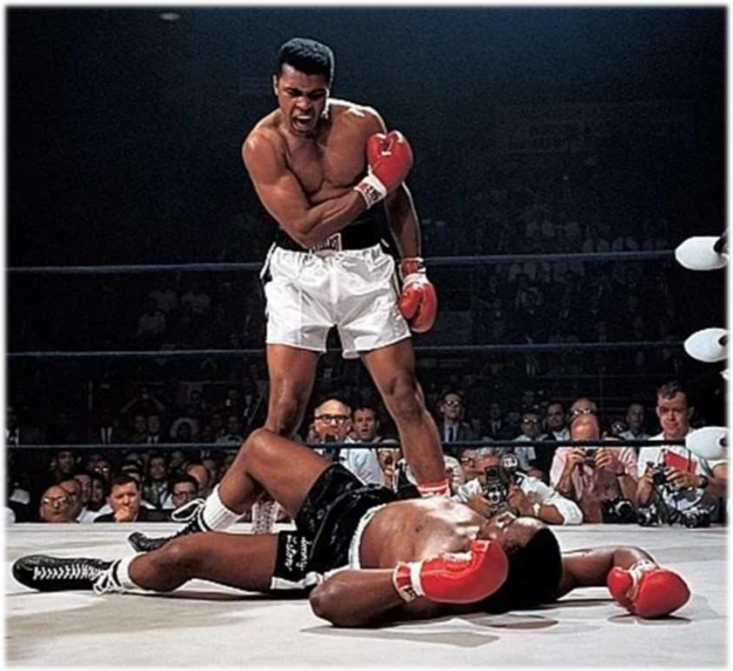
Prof Ross Tucker

24 May 2022

From first principles: Why does women's sport exist?

Why do you compete in sport with different categories? I notice that you have two gold medals in the Olympic 100m sprint, two Wimbledon singles titles, two Football World Cups?

107 kg, 1.91 m



88 kg, 1.80 m

68 kg, 1.73 m

What are we trying to reward in boxing?

If boxing did not have weight categories, then the important elements of boxing performance would be 'overwhelmed' by size, so the best boxers would be the biggest boxers. There would be limited reward for skill, speed, hand-eye co-ordination, balance, agility, endurance, relative strength and power, and Jones Jr and Mayweather Jr would "not exist"

The purpose of categories

SEX

Weight

Size & bulk overwhelm X

Age

Maturity overwhelms X

Paralympic classification scandal: 'Athletes are cheating in search of medals and money'

By **John Pring** on 2nd November 2017
Category: **Arts, Culture and Sport**

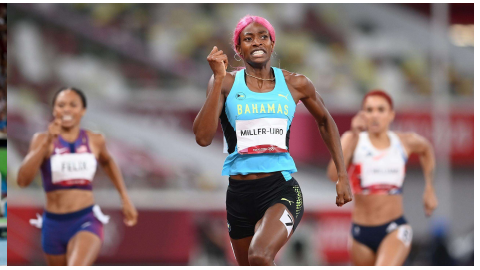
Listen

The system of Paralympic classification is being abused by cheating British athletes in search of money and medals, a disabled peer and retired Paralympian has told MPs.

Disability category

Relative ability overwhelms X

1.83, 70kg 43.03s



1.85, 69kg 48.36s

Women's sport exists as a category so that we can celebrate women champions like Ledecky, Williams, Miller-Uibo, Thompson-Herah, Woodman, Morgan.

We recognize equality only when we accept difference

Is the difference in performance between men and women large enough to require separate categories?

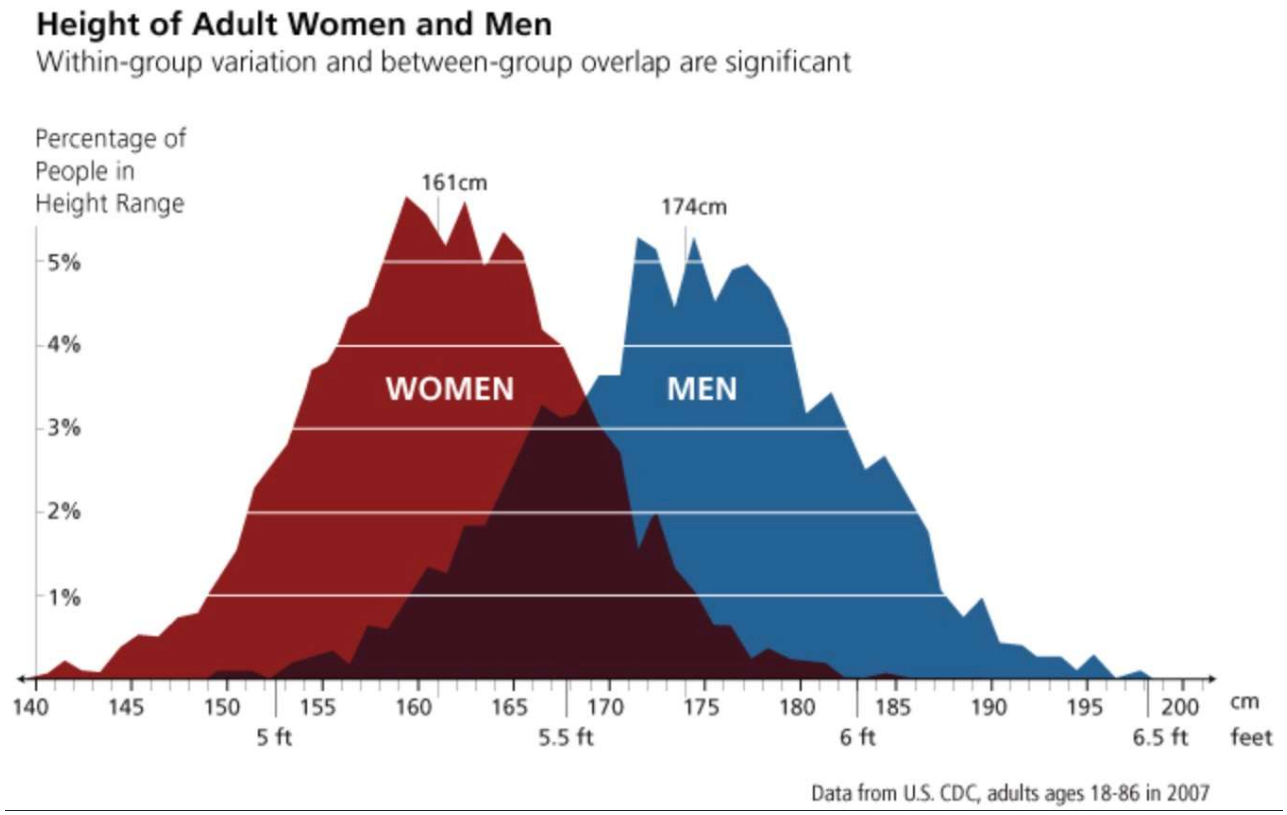
Bimodal distribution of secondary sex characteristics

This pattern is exactly what would be predicted if sex is binary (that is, two clear categories)

Note that overlap in attribute X does NOT disprove binary sex (a short or light male is not a female), just as a small dog is not a rabbit

Height Mass Strength Running speed

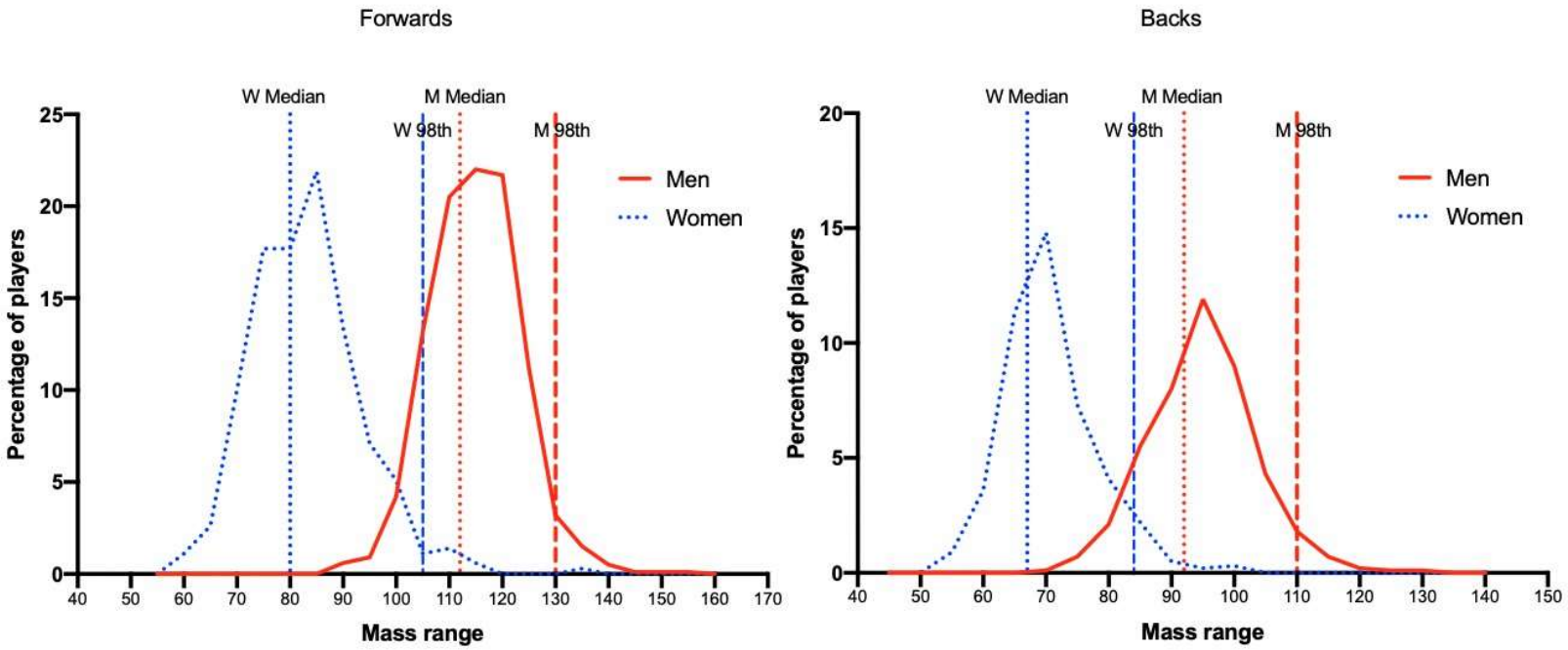
The example of height



- **8% difference in means and medians**
- **The tallest ± 5% of women are taller than the typical man**

You will find women who are taller than men. But you have to take a relatively tall woman, and compare them to a relatively short man. It's not 'like for like'

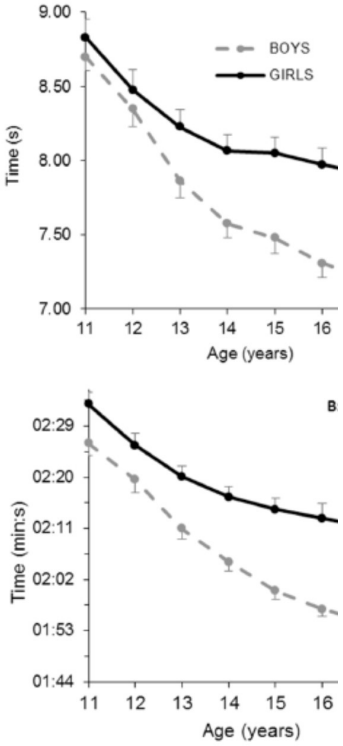
In elite rugby, there is less overlap – training exaggerates the biological difference

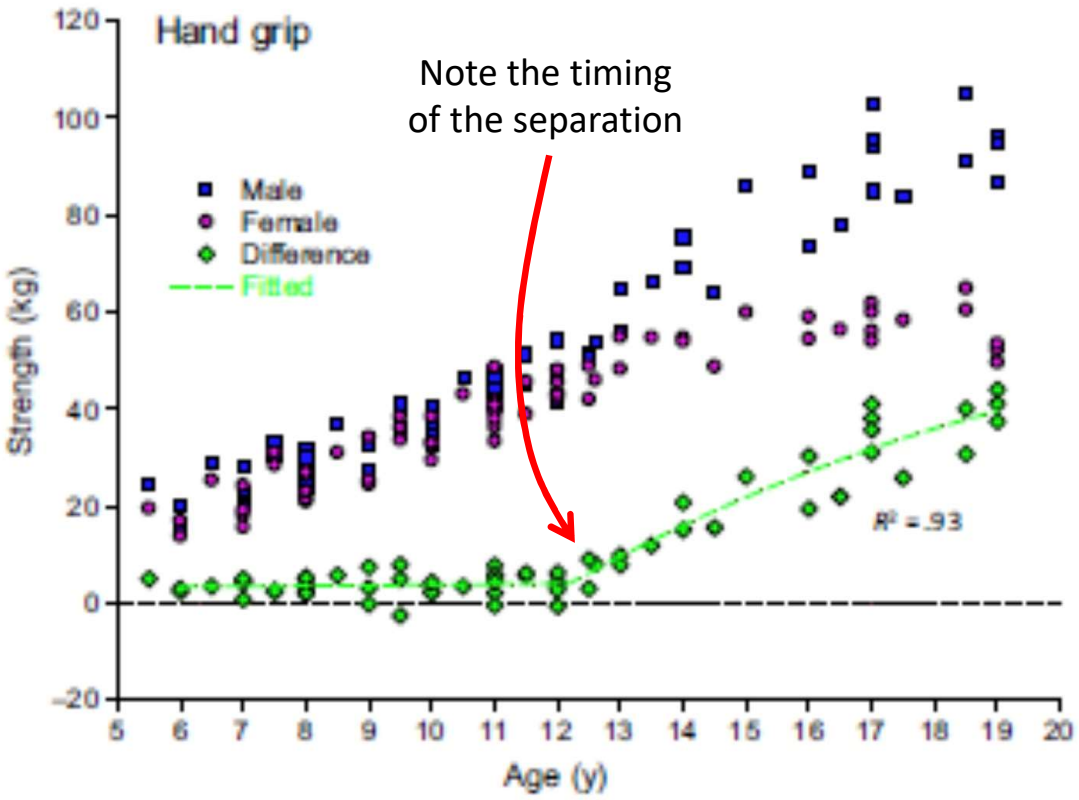


- The 98th percentile for women is lighter than the men's median
- The women's median is lighter than the men's 1st percentile
- The typical difference (between medians) is 41%

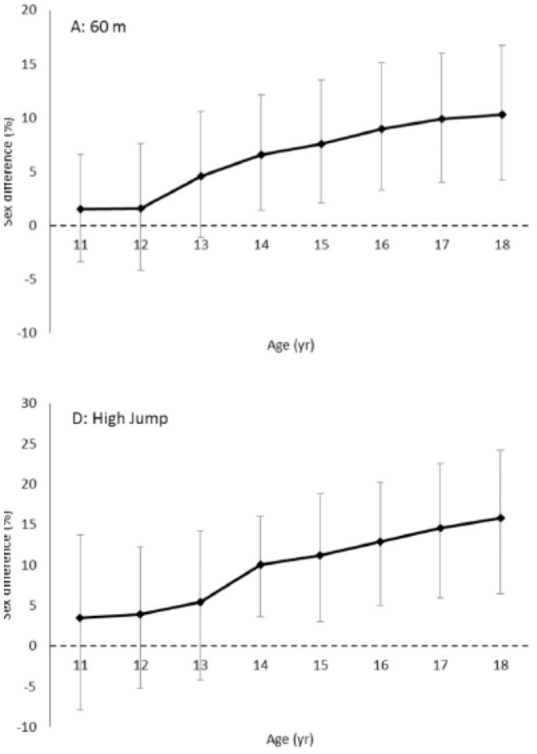
The foundations for male advantage

Actual performances by age



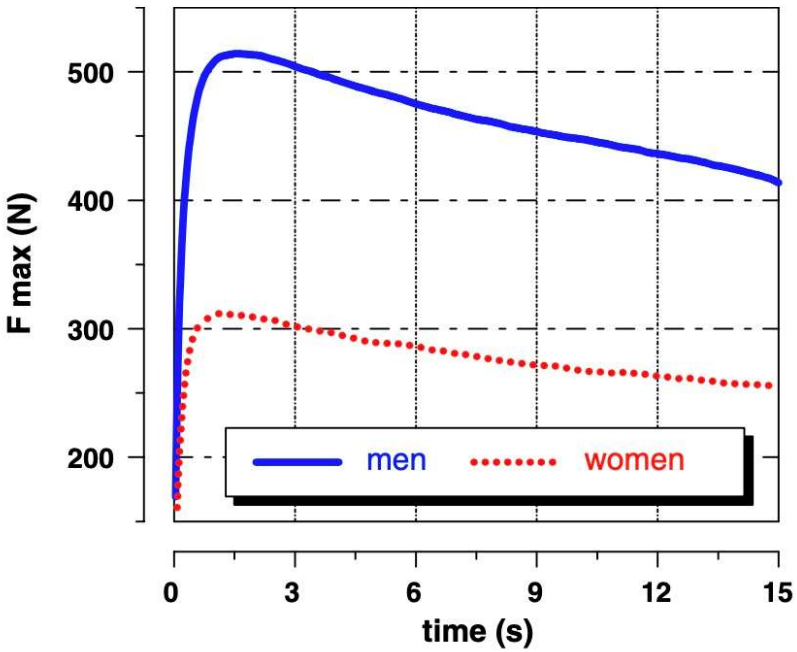


Percentage differences by age

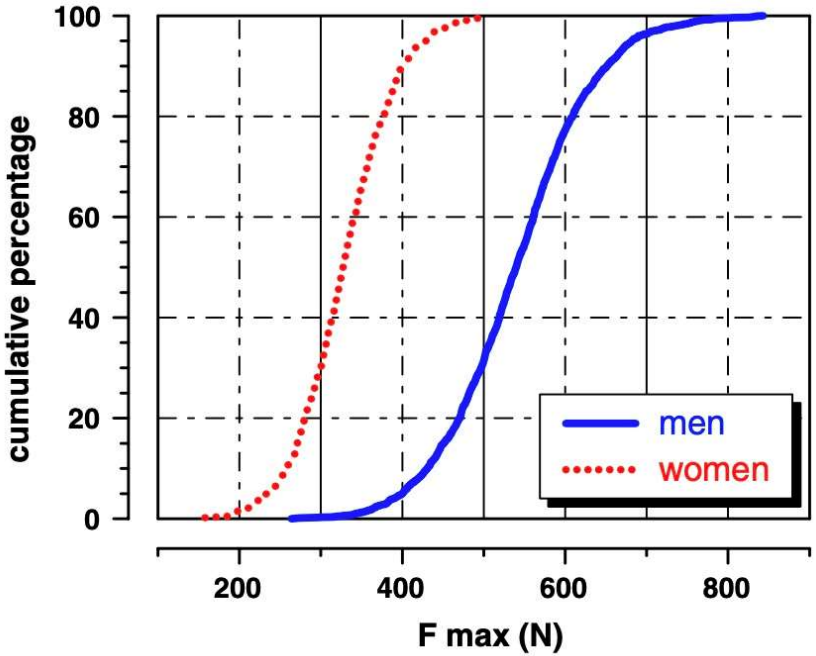


Adult strength differences

Hand grip strength, 1654 men and 533 women



Max (64%) and mean (66%) grip strength are higher in M

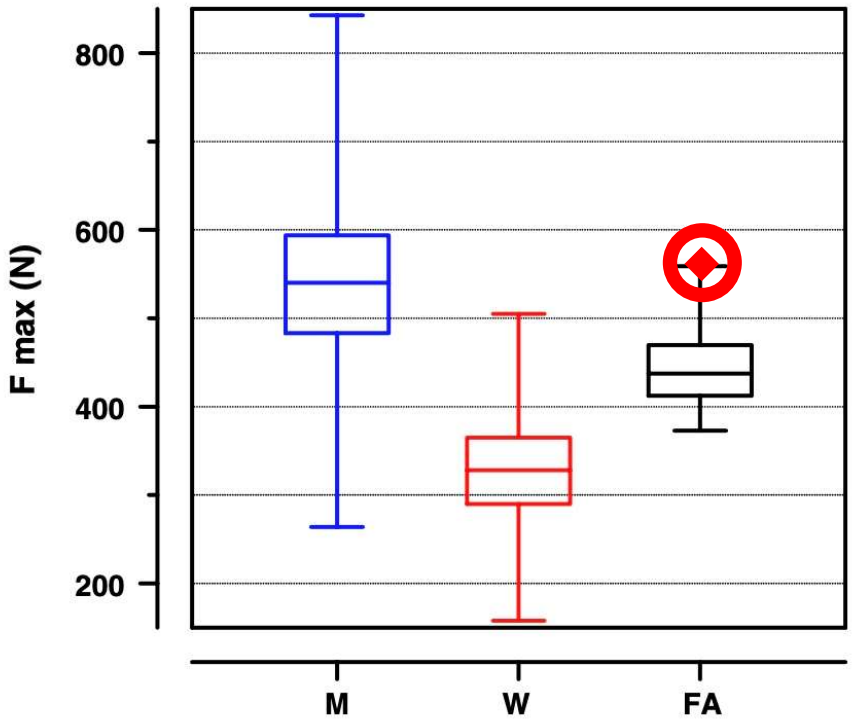


Strongest W – 33% of M

Adult strength differences

Hand grip strength, 1654 men and 533 women

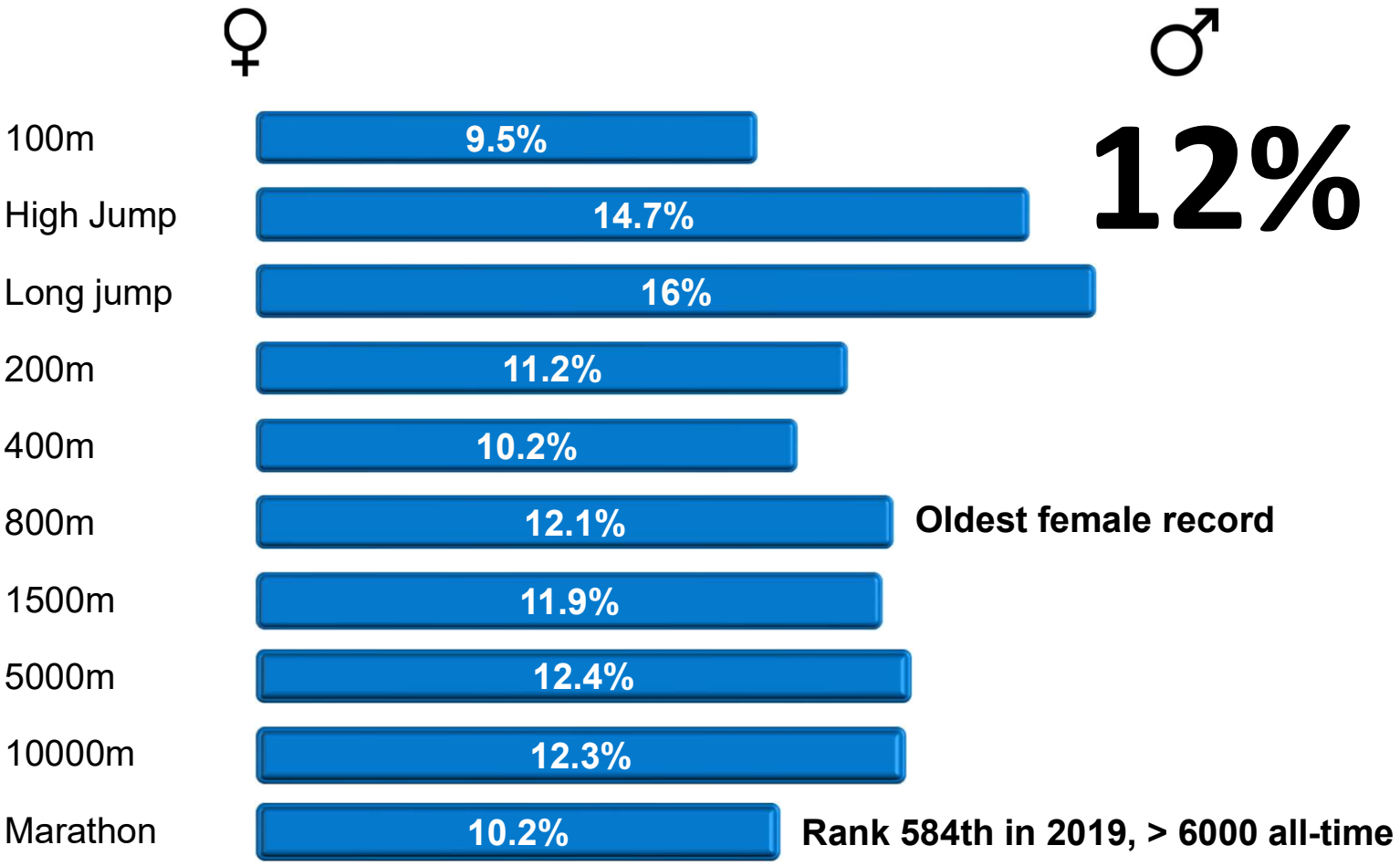
Part of the female group were elite, trained judo & handball athletes (n = 60)



On average, untrained M 23% stronger than elite FA

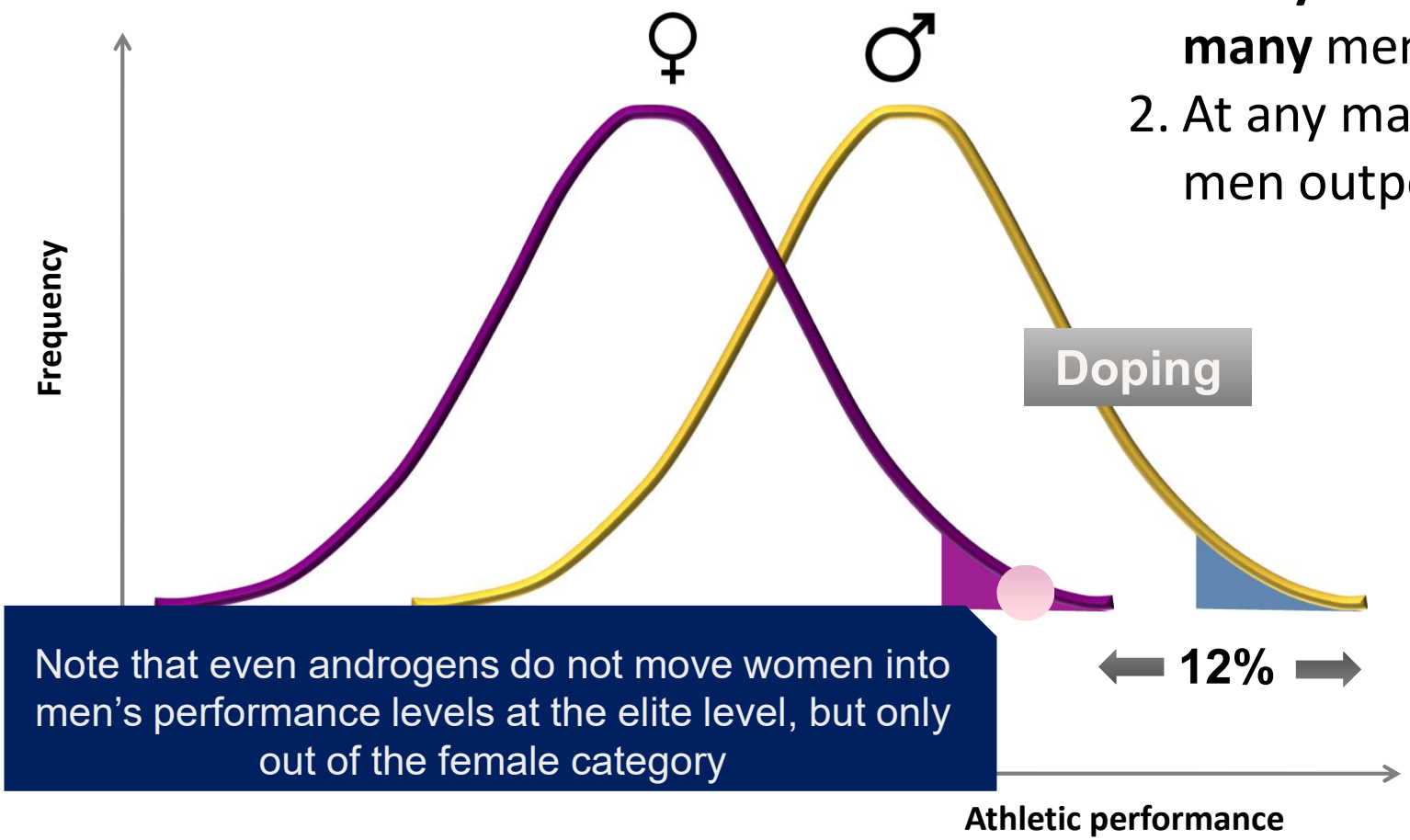
Strongest FA strength corresponds to 58th percentile of untrained M

Implications for sports performance



This is what 12% looks like

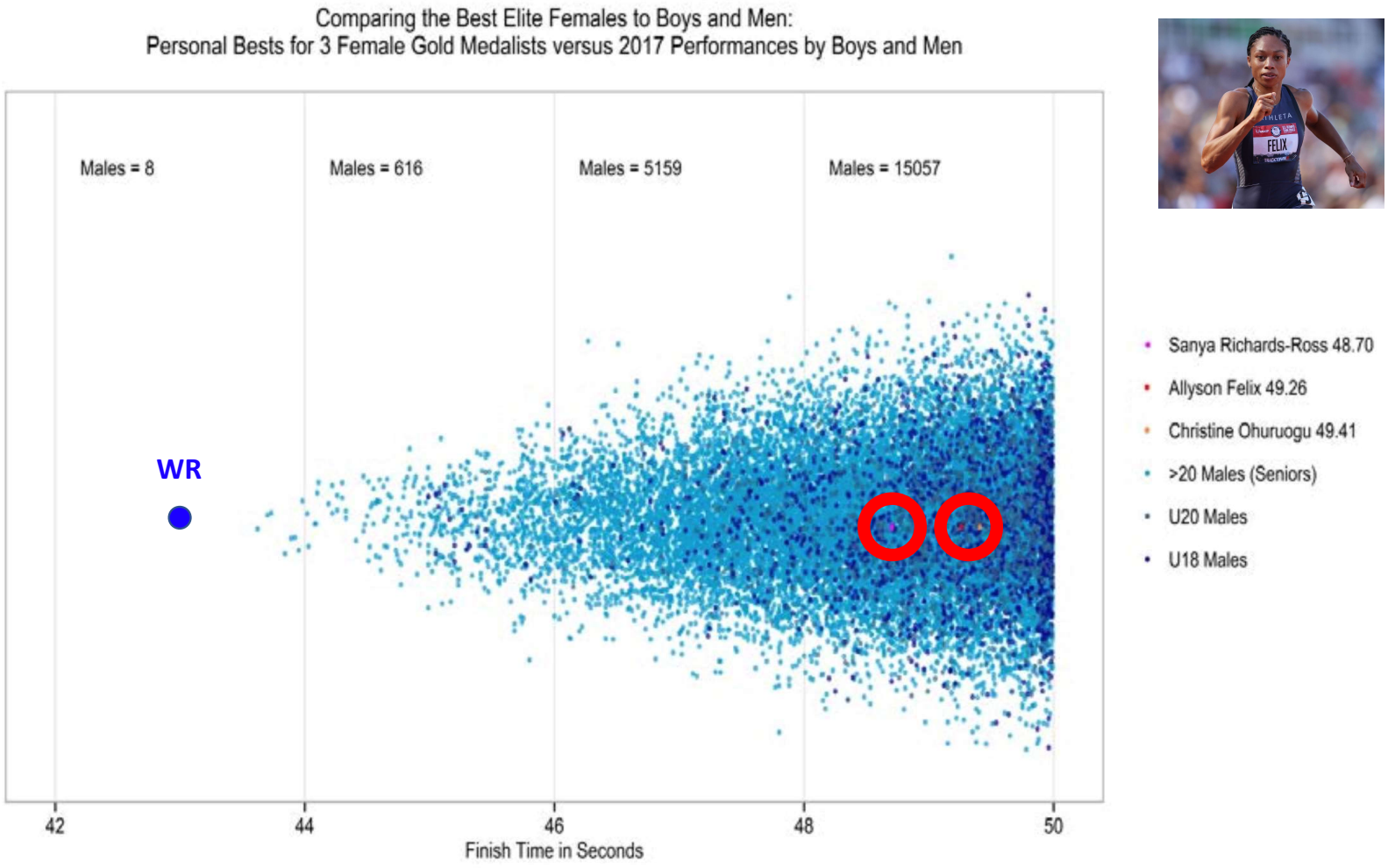
The conceptual challenge for elite sport



1. **Many** women outperform **many** men
2. At any matched level, **many** men outperform **all** women

Note that even androgens do not move women into men's performance levels at the elite level, but only out of the female category

Performance gap in elite sports



Performance gap in elite sports

TABLE 1 – World's Best Woman v. Under 18 Boys			
Event	Best Women's Result	Best Boys' Result	# of Boys Outperforming
100 Meters	10.71	10.15	124+
200 Meters	21.77	20.51	182
400 Meters	49.46	45.38	285
800 Meters	1:55.16*	1:46.3	201+
1500 Meters	3:56.14	3:37.43	101+
3000 Meters	8:23.14	7:38.90	30
5000 Meters	14:18.37	12:55.58	15
High Jump	2.06 meters	2.25 meters	28
Pole Vault	4.91 meters	5.31 meters	10
Long Jump	7.13 meters	7.88 meters	74
Triple Jump	14.96 meters	17.30 meters	47

TABLE 2 – World's Best Woman v. Number of Men Outperforming			
Event	Best Women's Result	Best Men's Result	# of Men Outperforming
100 Meters	10.71	9.69	2,474
200 Meters	21.77	19.77	2,920
400 Meters	49.46	43.62	4,341
800 Meters	1:55.16*	1:43.10	3,992+
1500 Meters	3:56.14	3:28.80	3,216+
3000 Meters	8:23.14	7:28.73	1307+
5000 Meters	14:18.37	12:55.23	1,243
High Jump	2.06 meters	2.40 meters	777
Pole Vault	4.91 meters	6.00 meters	684
Long Jump	7.13 meters	8.65 meters	1,652
Triple Jump	14.96 meters	18.11 meters	969

- In sprint and power events, hundreds of BOYS (younger than 18) outperform the best women in the world.
- In distance events, the number is between 50 and 100

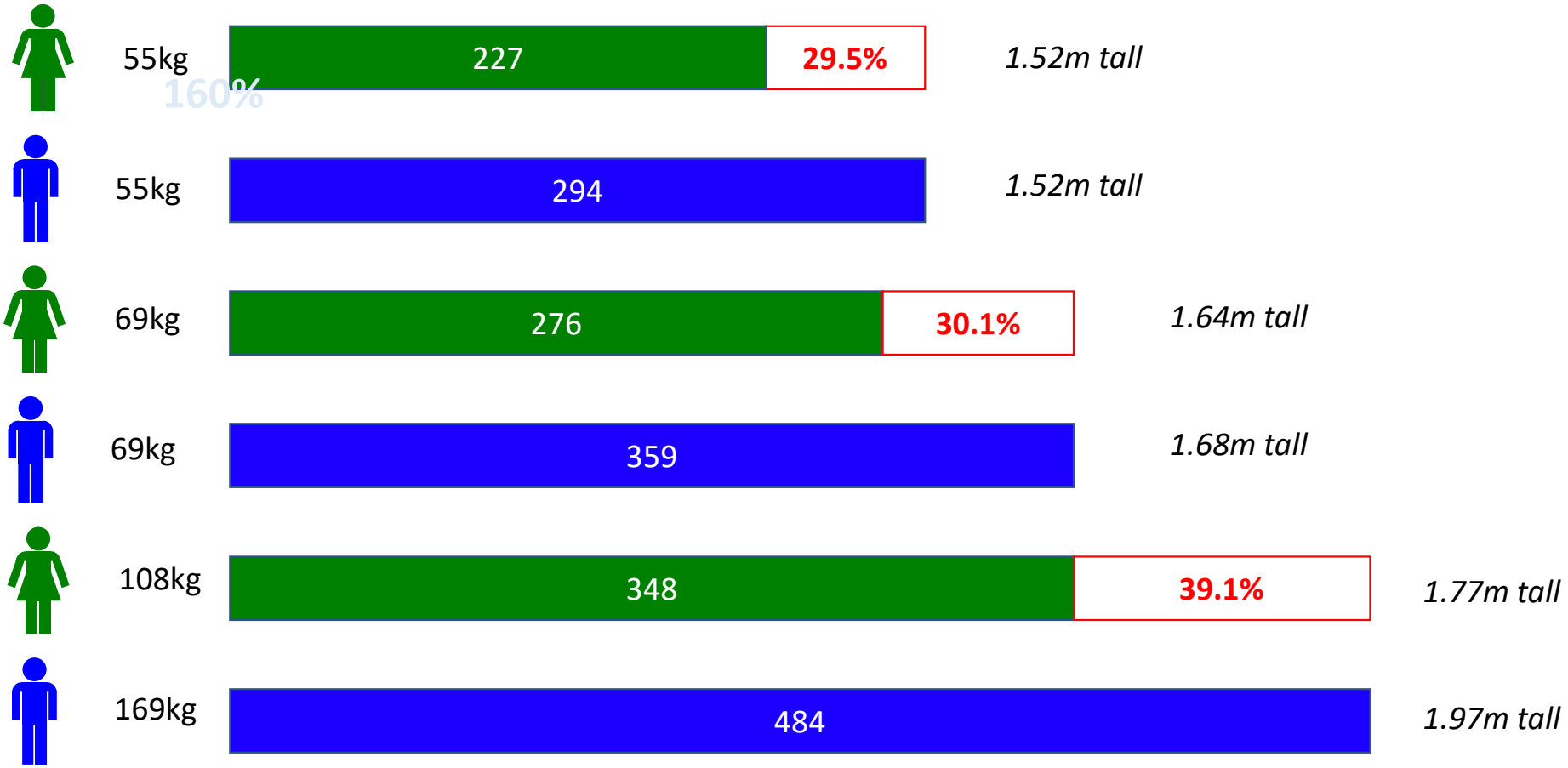
- In all events, thousands of men outperform the best women on an annual basis
- Remember that track and field events have the smallest male vs female gap

Upper body performance gaps

Junior Men's and Women's World Records (ages 15-20) for Clean and Jerk				
Men's weight (kg)	Record (kg)	Women's weight (kg)	Record (kg)	
56	171	58	142	**20.4%**
62	183	63	147	
69	198	69	157	**26.1%**
77	214	75	164	
85	220	90	160	**37.5%, despite 6% lighter**
94	233	+90	193	

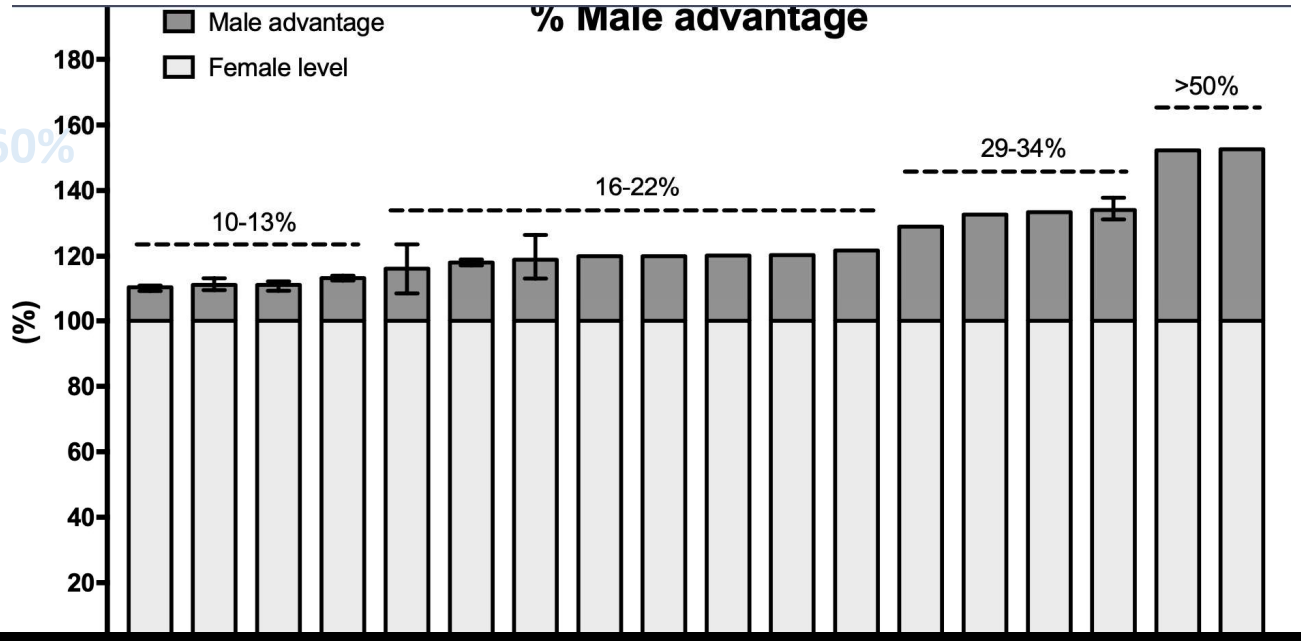
Junior men who weigh slightly the same as adult women are 26% stronger

Upper body performance gaps



- The biological differences between males and females are so large that without the “protection” of a separate category, those who do not have “biological male advantage” would disappear from most sport entirely

Functional performance gaps



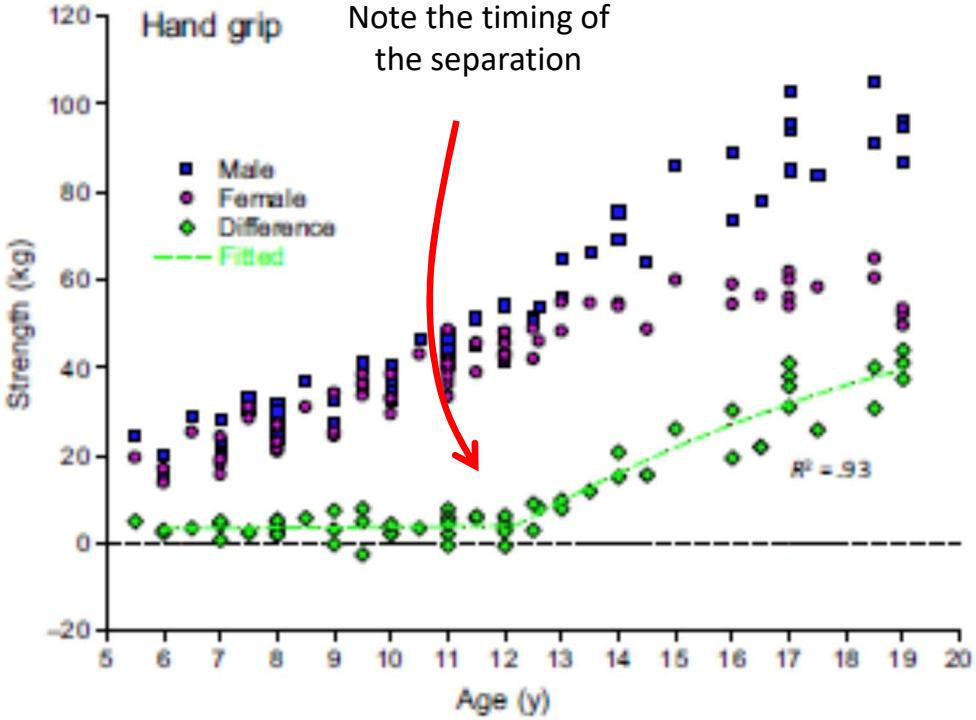
An important reminder: This does not lessen the achievements of women athletes. All it means is that the rational protection of the women's category is essential in order to assign equal value to their performances

Women's sport exists as a category so that we can celebrate women champions like Ledecky, Williams, Miller-Uibo, Thompson-Herah, Woodman, Morgan.

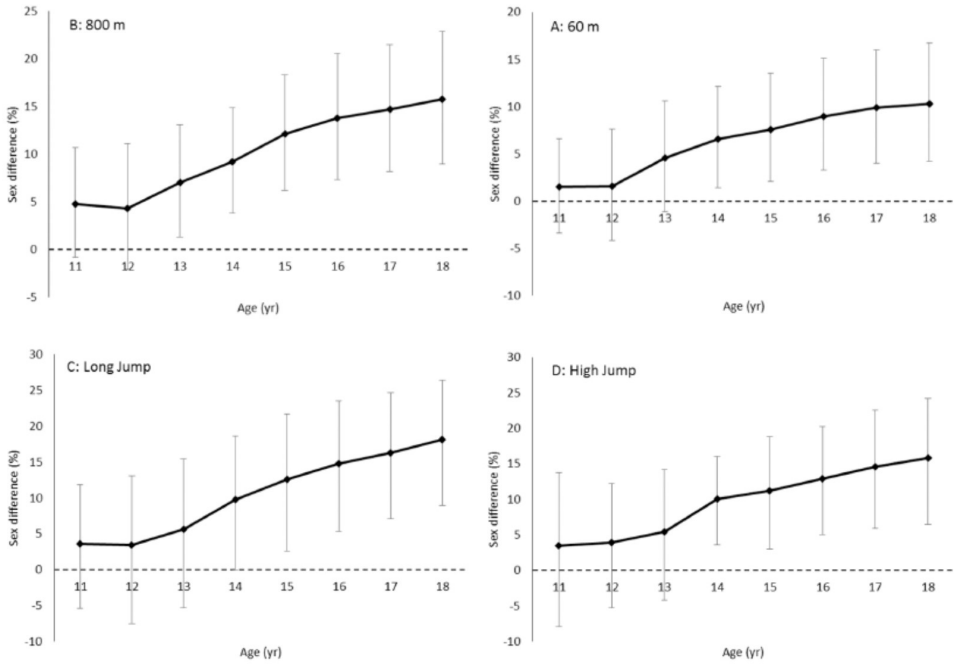
We recognize equality only when we accept BIOLOGICAL differences

Why do men's and women's performances differ so much?

The foundations for male advantage



Percentage differences by age

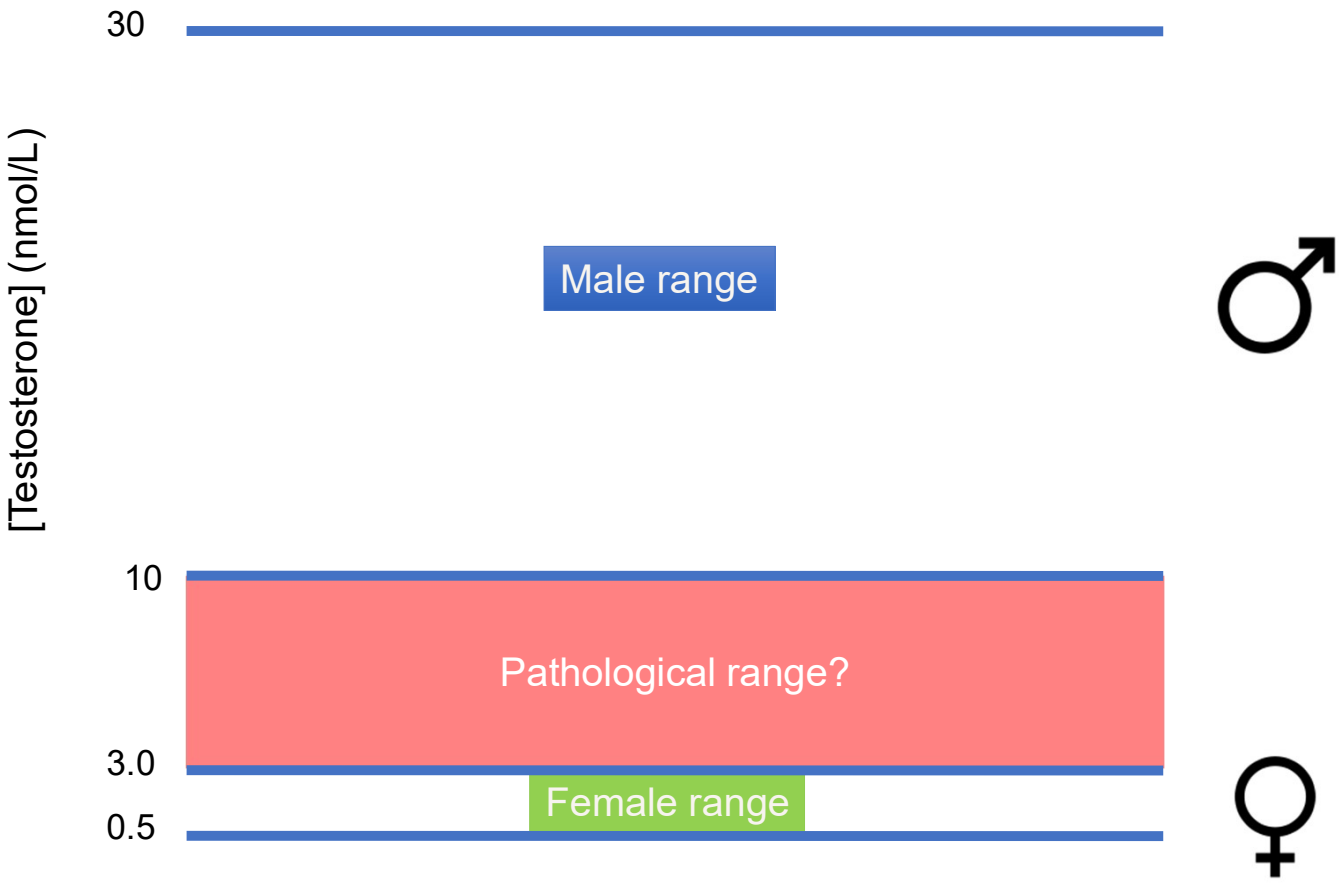


Androgens ⇒ **Biological attributes** ⇒ **Performance**

Testosterone & 'family'

Muscle mass & strength, skeleton, heart, lungs etc

The testosterone “gap”



Outcomes of androgenization

Variable	Magnitude of sex difference	References
VO2 max		
Absolute values	50%	Pate et al. (32)
Relative values	25%	
Respiratory function		
Cardiac output (maximal)	30%	Tong et al. (35)

There's no single variable, but a system that is changed by androgens

Women's sport exists as a category so that we can celebrate women champions like Ledecky, Williams, Miller-Uibo, Thompson-Herah, Woodman, Morgan.

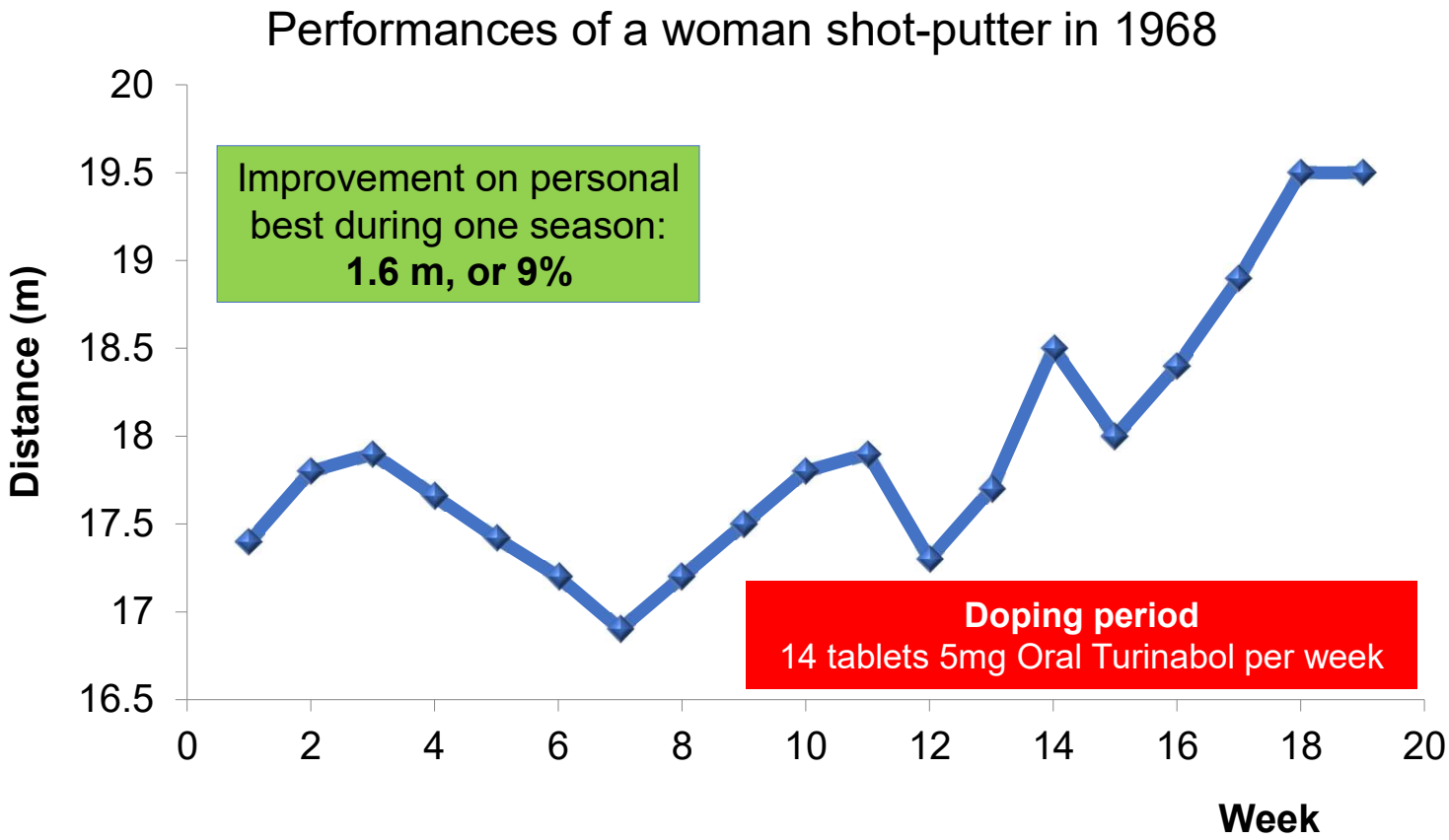
It achieves this objective by excluding the effects of androgens on biology and performance

Our first clue – SUPRA physiological performances

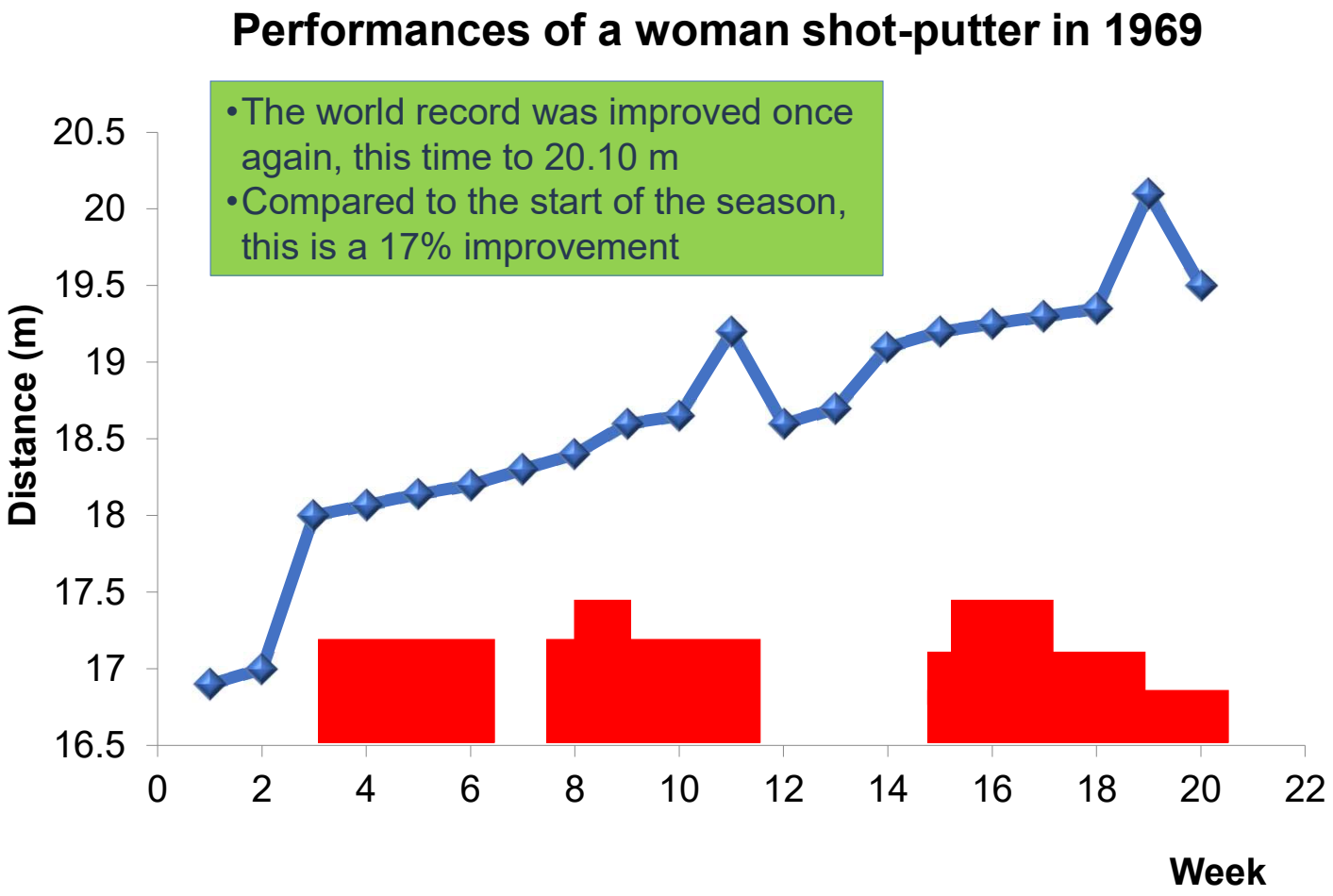
01	1:53.28	Jarmila Kratochvilová	1983
02	1:53.43	Nadezhda Olizarenko	1980
03	1:54.44	Ana Fidelia Quirot	1989
04	1:54.81	Olga Minyeva	1980
05	1:54.85	Yelena Soboleva	2008
06	1:54.87	Pamela Jelimo	2008
07	1:54.94	Tatyana Kazankina	1976
08	1:55.05	Doina Melinte	1982
09	1:55.19	Maria de Lurdes Mutola	1994
10	1:55.19	Jolanda Ceplak	2002
11	1:55.26	Sigrun Grau	1987
12	1:55.32	Christine Wachtel	1987
13	1:55.42	Nikolina Shtereva	1976
14	1:55.46	Tatyana Providokhina	1980
15	1:55.54	Ellen van Langen	
	1992		
16	1:55.54	Dong Liu	1993
17	1:55.56	Lyubov Gurina	1987
18	1:55.60	Elfi Zinn	1976
19	1:55.68	Ella Kovacs	1985
20	1:55.69	Irina Podyalovskaya	1984

Jarmila Kratochvilova
1:53.28 (WR) - 1983

Androgen effect



Androgens continued



The 2012 IAAF guidelines

849 female athletes at 2011 IAAF World Championships (2013 data added later)

5 doping (3.6 – 15.6 nmol/L)

5 XY DSDs (15.6 – 29.3 nmol/L)

4 α – 5 & 2 AIS

DSD & doping

839 remaining

ORIGINAL ARTICLE

Endocrine Research

Serum Androgen Levels in Elite Female Athletes

Patrick Fenichel, Stephen J. Bruce, Hugues Henry, Gabriel Dolle, and Martin Ritzen

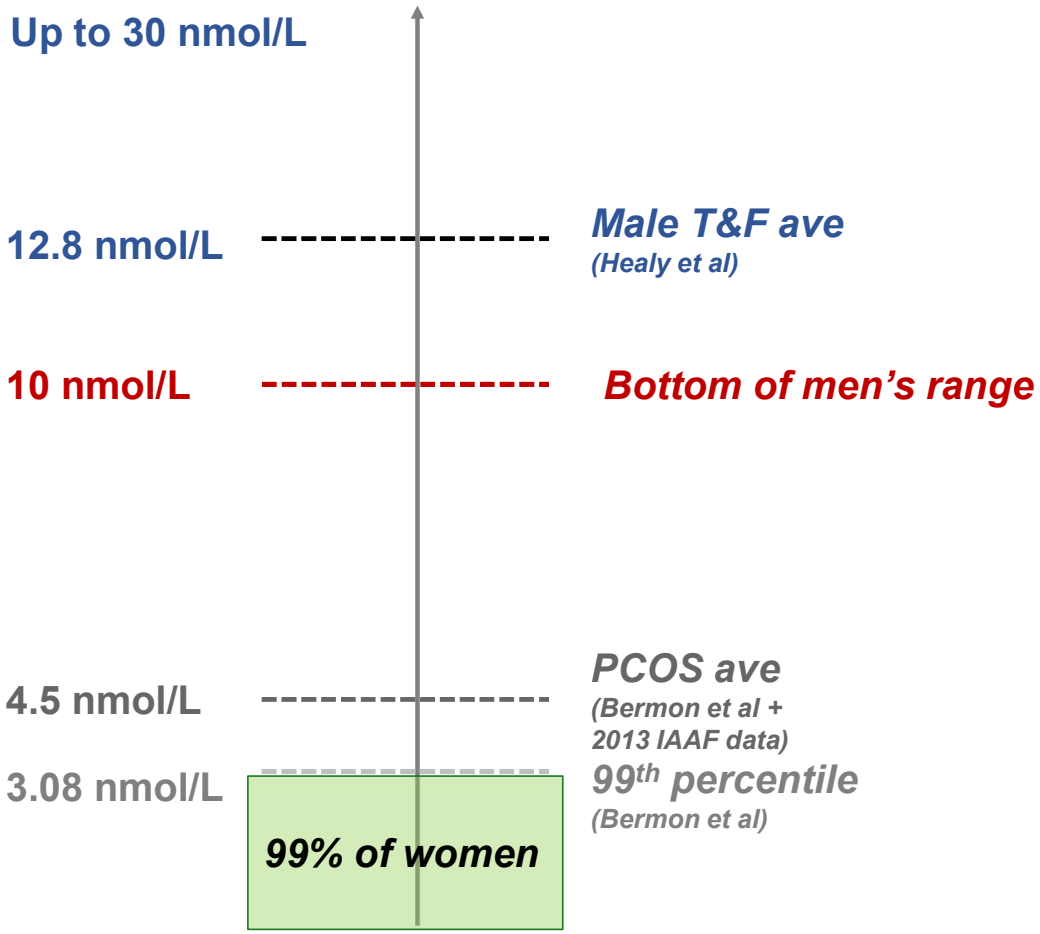
International Association of Athletics Federations Medical and Anti-Doping Department and Commission (S.B., P.Y.G., M.S., G.D.), Monaco; LAMHESS (S.B.), Nice Sophia Antipolis University, 06107 Nice, France; and Monaco Institute of Sports Medicine and Surgery (S.B.), 98000 Monaco; Department of Women's and Children's Health (A.L.H., M.R.), Karolinska Institutet and University Hospital, SE-141 86 Stockholm, Sweden; Swiss Laboratory for Doping Analyses (M.S., S.G., R.R., M.S.), University Centers of Legal Medicine, Geneva and Lausanne, and Centre Hospitalier Universitaire Vaudois and University of Lausanne, 1005 Lausanne, Switzerland; Department of Reproductive Endocrinology, and INSERM Unité 1065 (H.H.), Hôpital Archet, University Hospital of Nice, 06-003 Nice, France; Department of Clinical Chemistry (S.J.B., H.H.), Centre Hospitalier Universitaire, University Hospital of Lausanne, Vaudois, 1011 Lausanne, Switzerland

9 with T greater than 3 nmol/L

3 with T greater than 10 nmol/L (strong suspicion of doping)

99th percentile = 3.08 nmol/L

The IAAF cut-off



How has sport tried to resolve this issue in the past?

“The fix” was thought to be at the “source”

3.2 To be eligible to participate in the female category of competition at an International Event, a Transgender female athlete must satisfy the following requirements (together, the

3.2.3 she must keep her serum testosterone concentration below 5 nmol/L for so long as she continues to compete in the female category of competition.

3C. Provisions applicable to all Transgender athletes

3.3 For the avoidance of doubt, no athlete will be forced to undergo any medical assessment and/or treatment. It is the athlete's responsibility, in close consultation with his/her medical team, to decide on the advisability of proceeding with any assessment and/or treatment. However, deciding not to do so may have consequences in terms of the athlete's eligibility to participate in International Events in the category of competition that is consistent with his/her gender identity, in accordance with these Regulations.

3.4 For the further avoidance of doubt, the following are not required in order for a Transgender athlete to compete in the category of competition at an International Event that is consistent with his/her gender identity (because such requirements are not relevant to the imperatives identified above):

3.4.1 legal recognition of the athlete

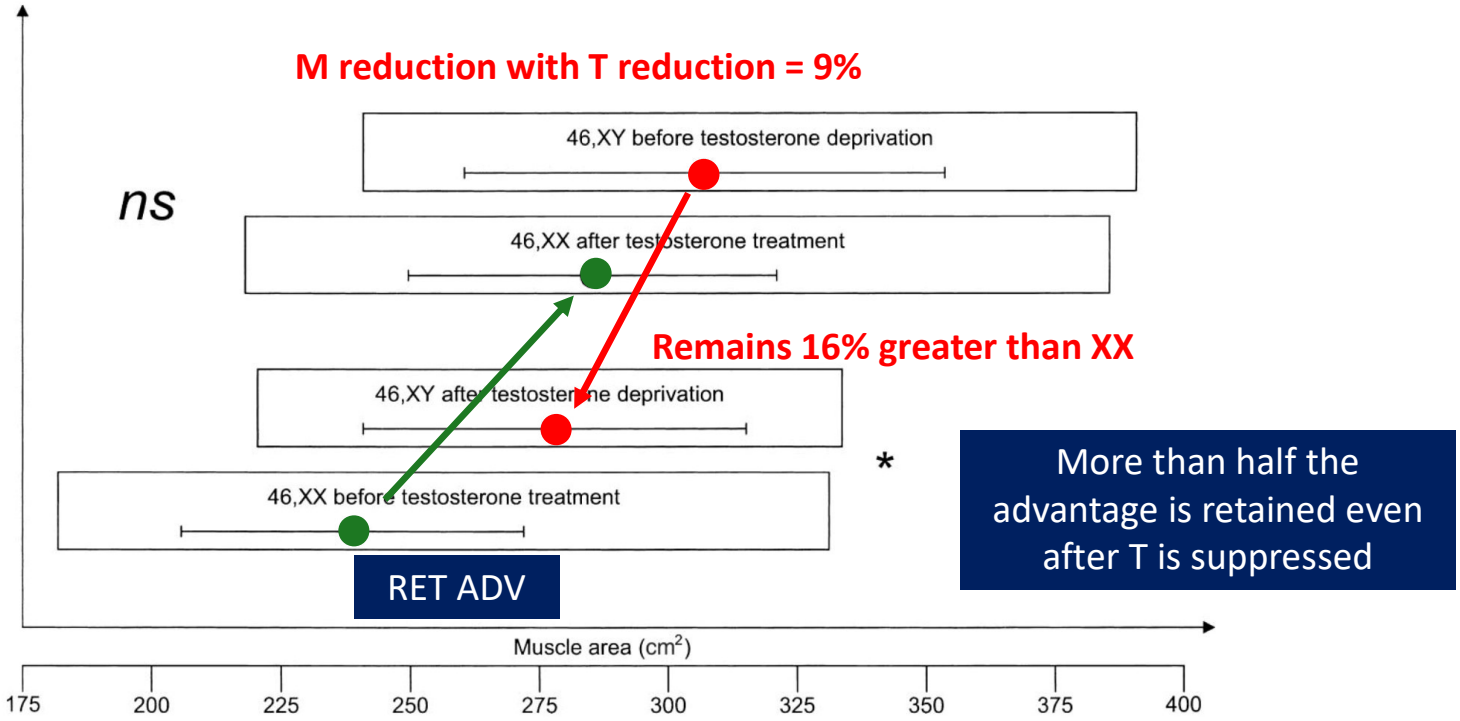
3.4.2 surgical anatomical changes.

The sports authorities placed an ‘all-in’ bet on T reduction as the way to ensure fairness & safety. Their rationale was that if the source of advantage is T, then lowering T would remove it

So does this ‘fix’ work?

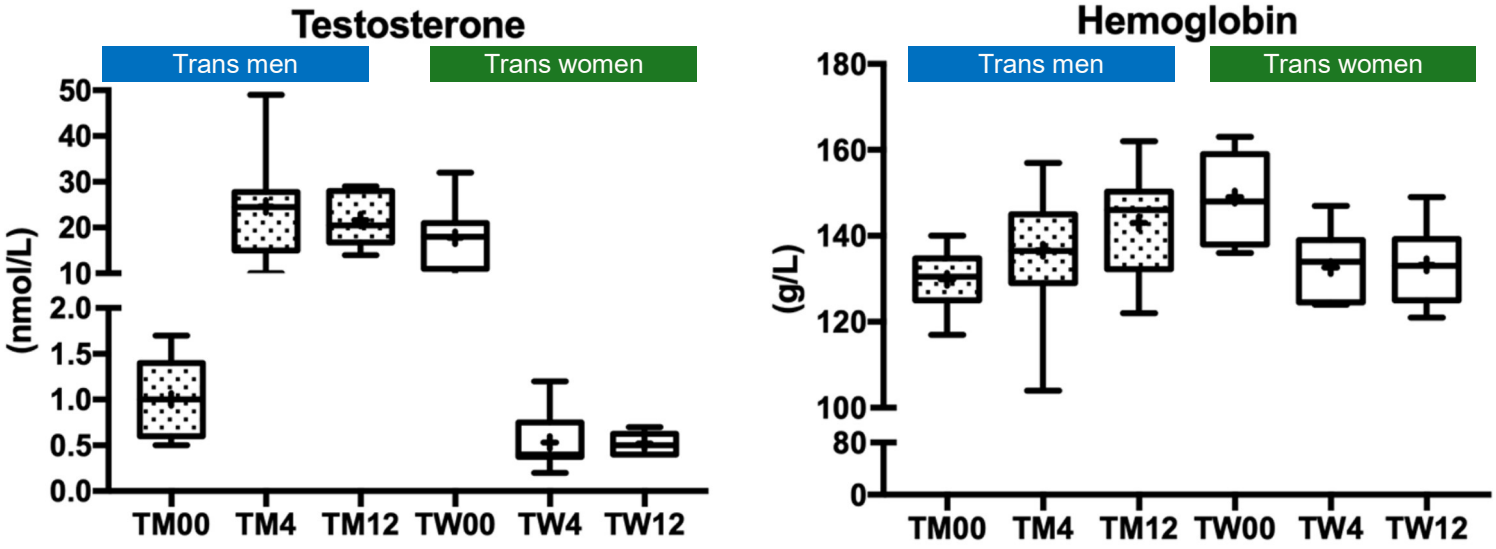
Change in muscle area with T reduction

M vs F initial difference ~ 30%



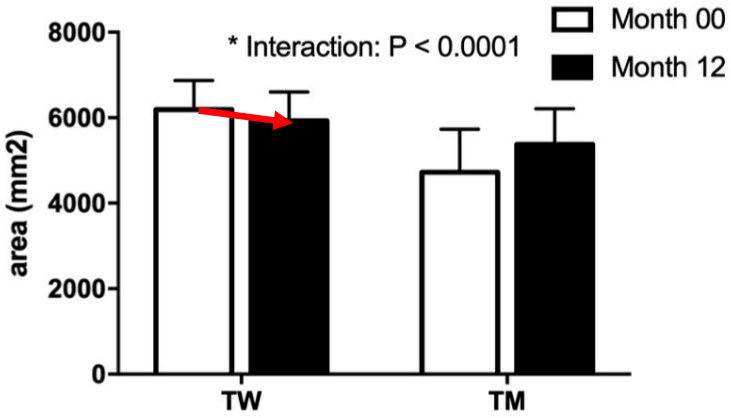
More than half the advantage is retained even after T is suppressed

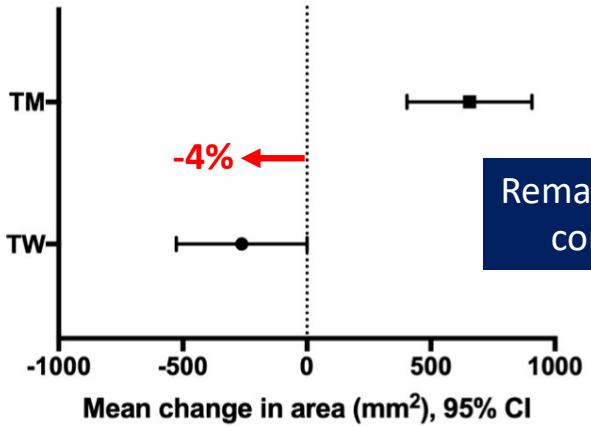
Effect of T suppression on physiology



Hemoglobin does respond rapidly to T suppression, and reaches levels similar to those of females within four months

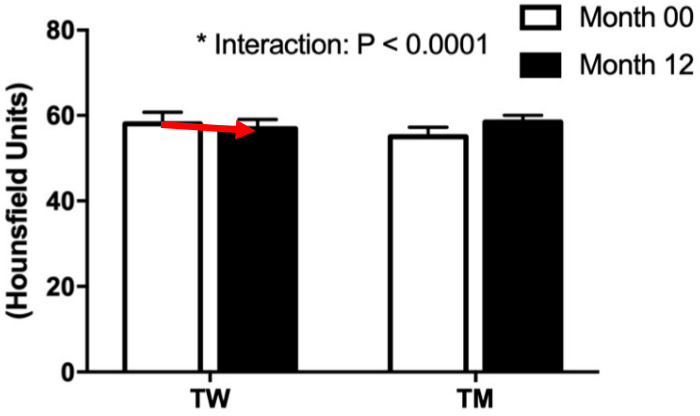
Quadriceps area

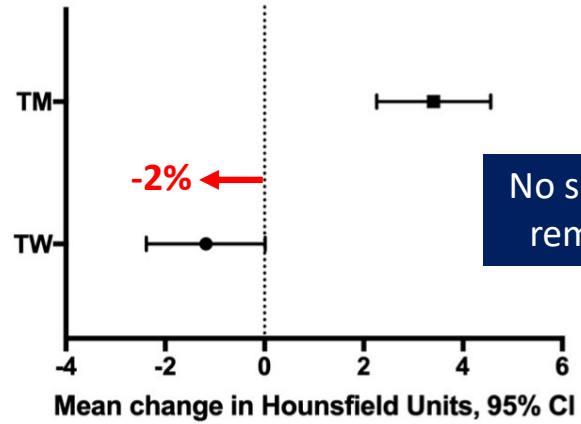




Remains 26% higher than comparison female

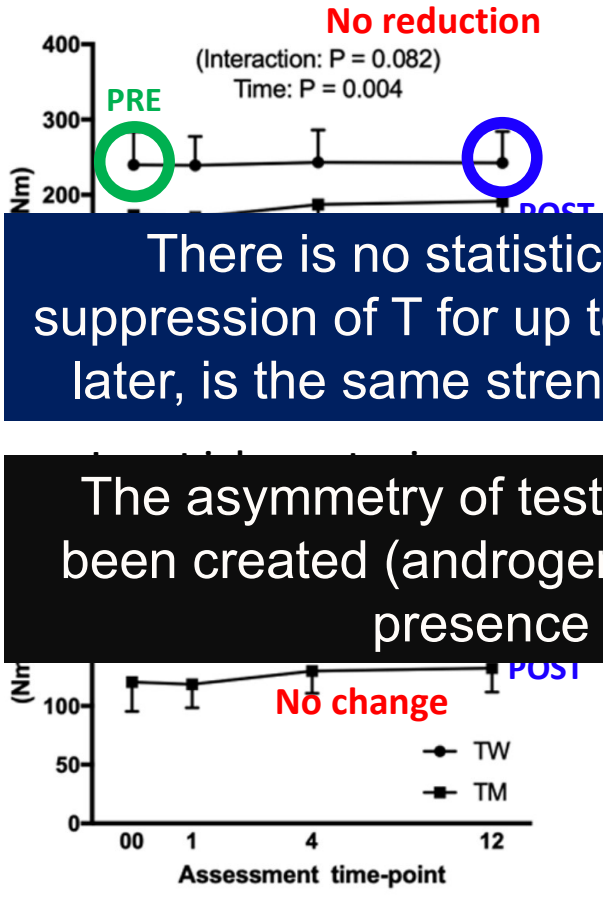
Quadriceps radiological density





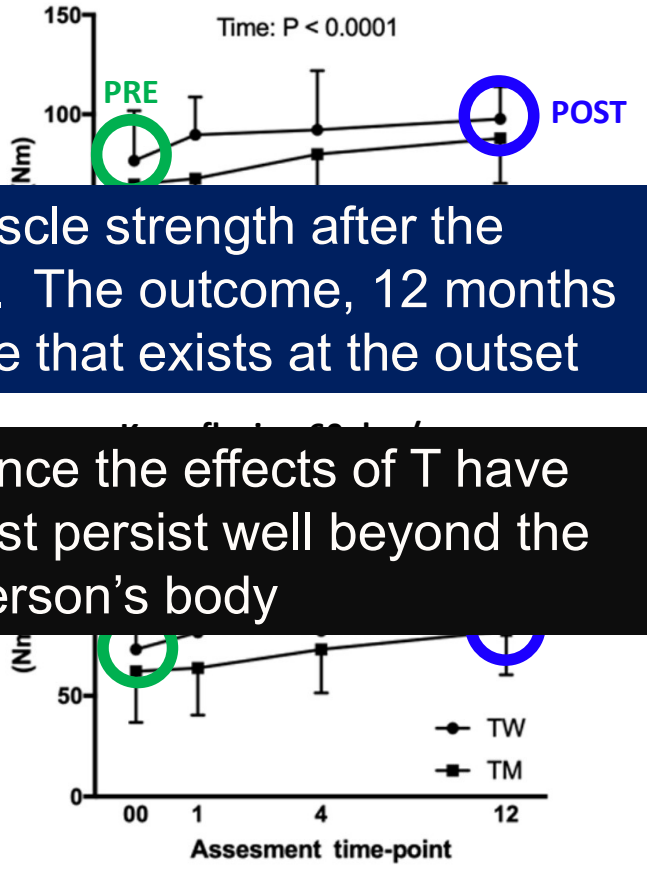
No significant reduction, remains higher than F

Does strength change when T is suppressed?



Knee extension 60 deg/s

25% - 40% differences M vs F



Knee flexion 90 deg/s

There is no statistical loss of muscle strength after the suppression of T for up to 12 months. The outcome, 12 months later, is the same strength difference that exists at the outset

The asymmetry of testosterone – once the effects of T have been created (androgenization), most persist well beyond the presence of T in the person's body

Does T reduction remove the biological differences?

The biological differences:

Variable	Magnitude of sex difference	References
Body composition		
Lean body mass	45%	Lee et al. (25)
Fat%	-30%	
Muscle mass		
Lower body	33%	Janssen et al. (26)
Upper body	40%	
Muscle strength		
Grip strength	57%	Bohannon et al. (27)
Knee extension peak torque	54%	Neder et al. (28)
Anthropometry and bone geometry		
Femur length	9.4%	Jantz et al. (29)
Humerus length	12.0%	Brinckmann et al. (30)
Radius length	14.6%	
Pelvic width relative to pelvis height	-6.1%	
Tendon properties		
Force	83%	Lepley et al. (31)
Stiffness	41%	
VO2 max		
Absolute values	50%	Pate et al. (32)
Relative values	25%	
Respiratory function		
Pulmonary ventilation (maximal)	48%	Åstrand et al. (33)
Cardiovascular function		
Left ventricular mass	31%	Åstrand et al. (33)
Cardiac output (rest)	22%	Best et al. (34)
Cardiac output (maximal)	30%	Tong et al. (35)
Stroke volume (rest)	43%	
Stroke volume (maximal)	34%	
Hemoglobin concentration	11%	

Range from 10% to 190% (30 to 50% for mass, 40 to 60% for strength, 30% for power)

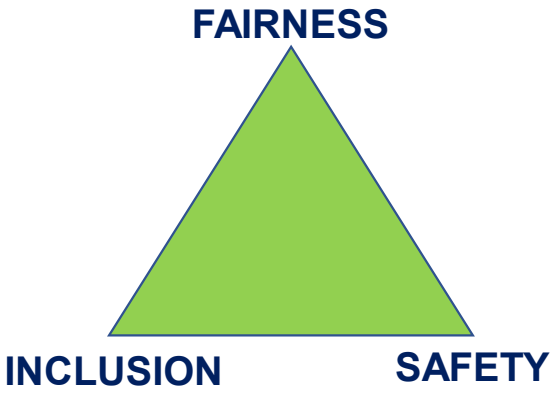
Selected changes with T suppression

Study	Participants (age)	Therapy	Confirmed serum testosterone levels	Muscle/strength data	Comparison with reference females
Gooren and Bunck 2004 [57]	N=19 TW 26±6 yr	T suppression + E supplementation	≤1 nmol/L at 1 and 3 yr	**Thigh area** 1 yr -9% / 3 yr -12%	**Thigh area** 1 yr 16% / 3 yr 13%
Haraldsen et al. 2007 [58]	N=12 TW 29±8 yr	E supplementation	<10 nmol/L at 3 mo and 1 yr	**LBM** 3 mo / 1 yr - small changes, unclear magnitude	
Mueller et al. 2011 [59]	N=84 TW 36±11 yr	T suppression + E supplementation	≤1 nmol/L at 1 and 2 yr	**LBM** 1 yr -4% / 2 yr -7%	
Wierckx et al. 2014 [60]	N=53 TW 31±14 yr	T suppression + E supplementation	<10 nmol/L at 1 yr	**LBM** 1 yr -5%	**LBM** 1 yr 39%
Van Caenegem et al. 2015 [51]	N=49 TW 33 ±14 yr	T suppression + E supplementation	≤1 nmol/L at 1 and 2 yr	**LBM** 1 yr -4% / 2 yr -0.5% **Grip strength** 1 yr -7% / 2 yr -9% **Calf area** 1 yr -2% / 2 yr -4% **Forearm area** 1 yr -8% / 2 yr -4%	
Gava et al. 2016 [61]	N=40 TW 31 ±10 yr	T suppression + E supplementation	<5 nmol/L at 6 mo and ≤ 1 nmol/L at 1 yr	**LBM** 1 yr -2%	
Auer et al. 2018 [62]	N=72 TW 35 ±1 (SE) yr	T suppression + E supplementation	<5 nmol/L at 1 yr	**LBM** 1 yr -3%	**LBM** 1 yr 27%
Klaver et al. 2018 [63]	N=179 TW 29 (range 18-66)	T suppression + E supplementation	≤1 nmol/L at 1 yr	**LBM 1 yr** total -3% arm region -6% trunk region -2% android region 0% gynoid region -3% leg region -4%	**LBM 1 yr** total 18% arm region 28% leg region 19%
Fighera et al. 2018 [64]	N=46 TW 34±10	E supplementation with or without T suppression	<5 nmol/L at 3 mo ≤1 nmol/L at 31 mo	**ALM** 31 mo -4% from the 3 mo visit	
Scharff et al. 2019 [65]	N=249 TW 28 (inter quartile range 23-40)	T suppression + E supplementation	≤1 nmol/L at 1 yr	**Grip strength** 1 yr -4%	**Grip strength** 1 yr 21%
Wiik et al. 2019 [66]	N=11 TW 27±4	T suppression + E supplementation	≤1 nmol/L at 4 mo and at 1 yr	**Thigh volume** 1 yr -5% **Quad area** 1 yr -4% **Knee extension strength** 1 yr 2% **Knee flexion strength** 1 yr 3%	**Thigh volume** 1 yr 33% **Quad area** 26% **Knee extension strength** 41% **Knee flexion strength** 33%

N = number of participants. TW – transgender women. yr – year. mo – month. T – testosterone. E – estrogen. ± standard deviation (unless otherwise indicated in text). LBM – lean body mass. ALM – appendicular lean mass. Tack et al. [67] was not included in the table since some of the participants had not undergone full puberty at treatment initiation.

Reduced by 0% to 10% for mass (total and muscle), strength, no change for bone density

The choice that sport must make



All the biological evidence we have suggests that we cannot have inclusion (of TW into women's sport) AND fairness/safety

There is no compromise solution that maintains fairness AND allows for inclusion

Inclusion happens at the expense of fairness. Fairness can only be achieved if the boundary around women's sport is defended rigidly

In the absence of 'balance', sport has to choose. This requires recognition of prioritization. Which matters more?

Why is this a problem? There haven't been any trans women Olympic champions, for instance?

Scarcity as an argument for inclusion

How many heavyweights would be acceptable in lightweight boxing? How many adults in children's sport?

If a heavyweight boxer didn't beat a lightweight, or if an adult didn't win a youth sporting competition, would it make their participation acceptable to those in the category they entered?

Having an advantage is not measured by the final outcome. Advantage can only be measured "within self" (pre vs post, with vs without), not between people. If a cyclist rides with a motor in their bicycle, does it guarantee that they'll win? And if they don't, is it fair?

The process of evaluation

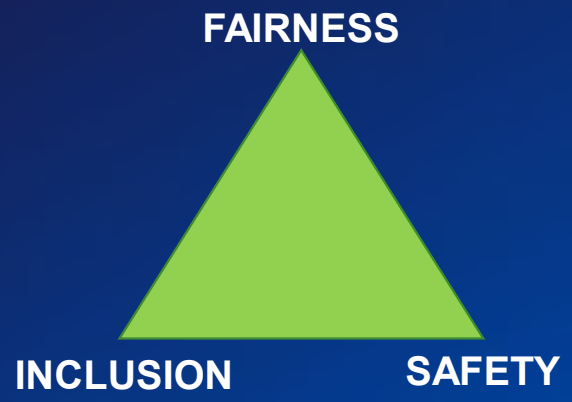
2. Historical assessment and solution

- Previous policy required lowering of T to remove advantages and enable inclusion without undermining fair competition. ”The Fix”
- Introduces the concept of balancing priorities/incentives

*“it is necessary to ensure **insofar as possible** that trans athletes are not excluded from the opportunity to participate in sporting competition"*

vs

*‘‘the overriding sporting objective is and remains the **guarantee of fair competition**”*

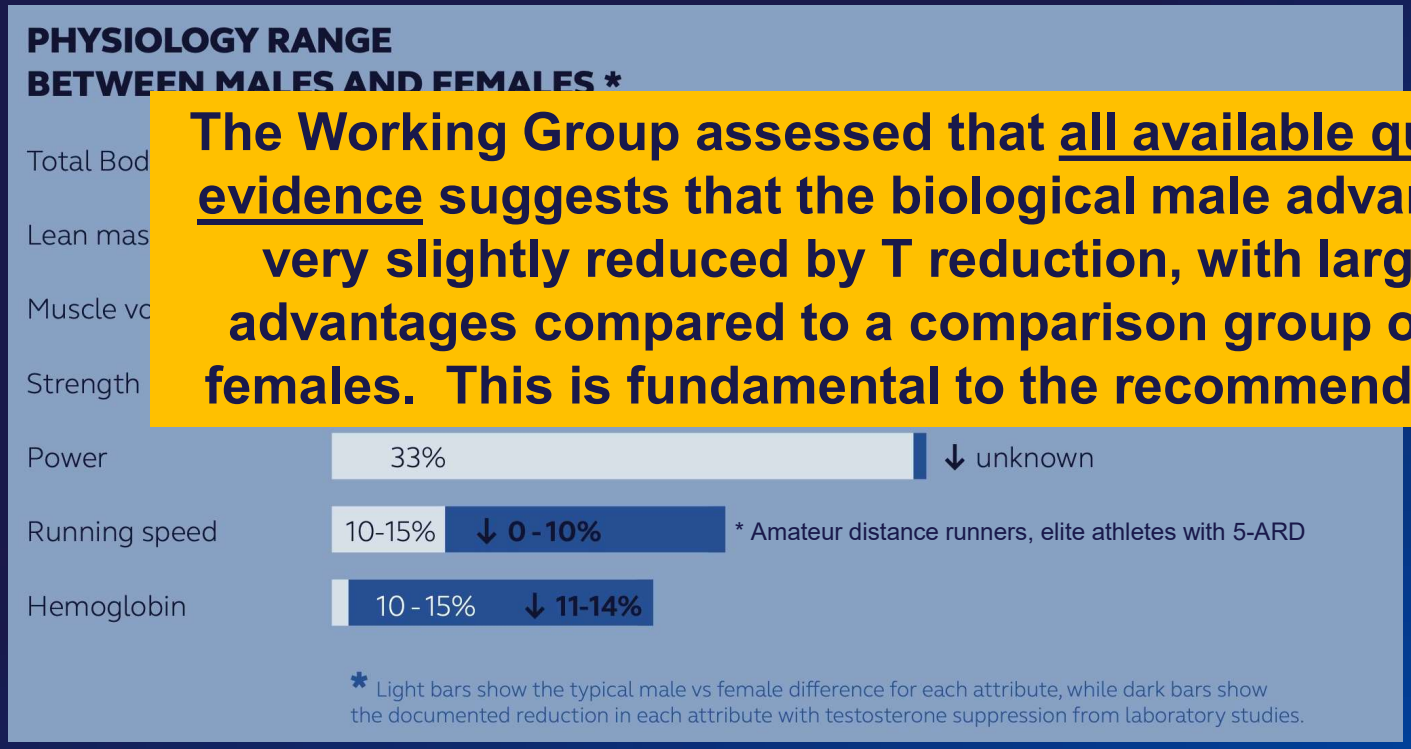


The fundamental question: Is there evidence that the “fix” works?
If yes, then the ‘triangle’ holds with each corner satisfied.
If no, then a decision must be made to prioritize one ”corner” over others

The process of evaluation

3. Evidence for the effectiveness of T suppression on biology

- Research studies, longitudinal and cross-sectional, examining how biology relevant to performance is affected by T suppression



The Working Group assessed that <u>all available quality current evidence</u> suggests that the biological male advantage is only very slightly reduced by T reduction, with large retained advantages compared to a comparison group of biological females. This is fundamental to the recommendations made

- 12 Longitudinal
  studies
  women
  lly trained
  ding for
  evant to
  rugby

WORLD RUGBY

Isn’t sport all about natural advantages?
Some people have exceptional physiology
and others do not

“Exceptional physiology”

Usain Bolt

Elaine Thompson

Michael Phelps

Katie Ledecky

Which of the following statements is true?

Usain Bolt and Michael Phelps are 10-12% faster than Elaine Thompson and Katie Ledecky. Therefore:

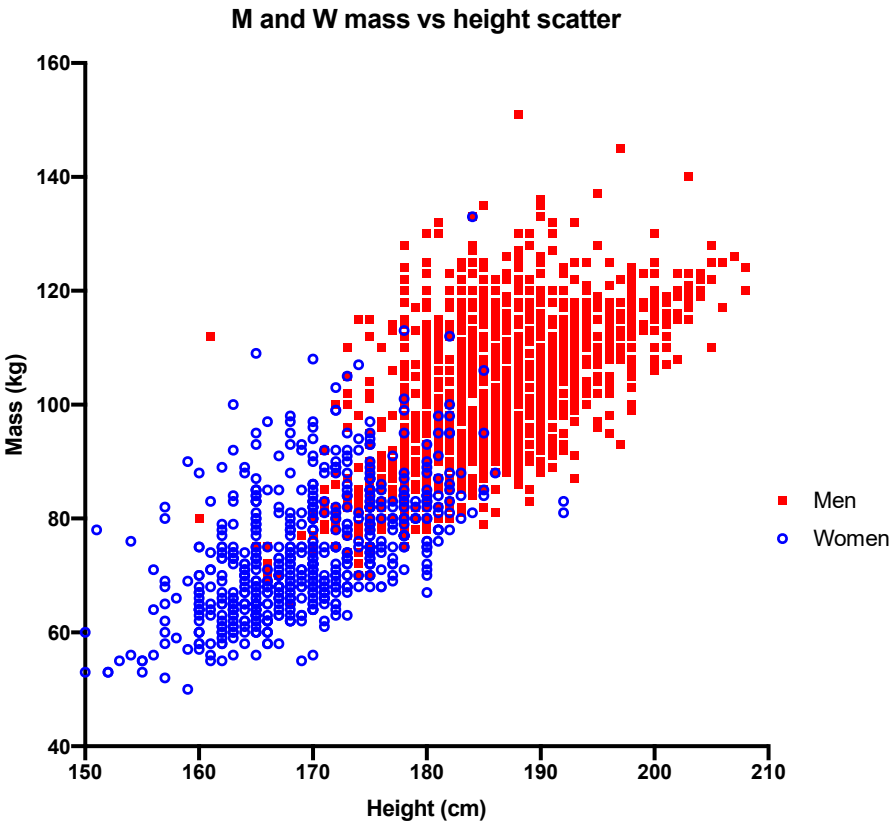
i) Bolt and Phelps are exceptional, while Thompson and Ledecky are relatively mediocre athletes

ii) Bolt and Thompson are equal, and Phelps and Ledecky are equal, both are exceptional

i) Is true if you apply this “athleticism is about about exceptional physiology” argument without respect for the impact of biological sex on performance

ii) Is true if you respect biological sex, and recognize that the category of women’s sport allows exceptional physiology to be expressed and recognized in women

What does overlap really mean? Careful what you wish for



What about tall women, and short men?
Why don't we stop them from competing?

This holds that because not all people in one group have the 'advantage', the advantage must not be worth regulating

The logic being applied here ends with the total abolition of categories

The overlap is only found when comparing an extremely heavy W (heaviest 10%) to an extremely light M (lightest 10%)

At the other end of the spectrum (light W vs heavy M) the gap is 150%

“Natural advantage” theory is an argument against categories

Which of these boxers has “natural advantages”

107 kg, 1.91 m

88 kg, 1.80 m

The answer is that **BOTH Ali and Jones Jr have natural advantages**. But Ali, by virtue of size, bulk and length in a sport that rewards these attributes, has a “natural advantage” that cancels out and obscures the fact that both boxers are exceptional

Which of these swimmers has “natural advantages”

Both Phelps and Ledecky have natural advantages. **But Phelps has these natural advantages in a male physiological system**, Ledecky in a female physiological system (minus the androgens). But they are equal, both possessing a set of attributes for world-class swimming.

”Natural advantage” theory actually says that we should let sport be played out as a human race, freed from categories that exclude CERTAIN natural advantages. After all, if you believe the outcome should be determined by ‘natural advantages’, then let humans compete in one category. What is the prediction? All sports will be dominated by males, aged 20 to 32

There are some academics who have argued that testosterone is not actually a key determinant of performance. Are they wrong?

Example of the testosterone-denial rationale

This hormone doesn't dictate better athletic performance. T is involved in processes that underlie athletic performance for most people, but it's neither a sufficient nor even necessary ingredient. Take, for example, women with complete androgen insensitivity syndrome, who appear to be overrepresented among elite women athletes and for whom their tissues have no ability to respond to T at the cellular level. Just as T isn't simple, neither is athleticism.

Think of Usain Bolt, the fastest human in the world. Yet he isn't the fastest at every race. When asked why he never runs the 800m, he responded: "I've tried it and trained and my PR (personal record) is like 2:07, and that's really slow, like, a woman could beat me." The interviewer laughed him off, saying: "You're going to get in trouble for that!" But Bolt was serious: "It's true, though - they could!"

Karkazis, The Guardian, 2019

This thinking is flawed, both physiologically and statistically. It makes fundamental errors with respects to biology, and how variables within categories determine performance, and is **unequivocally incorrect**

Reality: Testosterone IS the crucial determinant of performance differences **BETWEEN** males and females, but it is not the differentiator **WITHIN** a group of males or **WITHIN** a group of females. Nor does a cherry-picked example of a male athlete who loses to female athletes disprove the effect of testosterone, because it is not a like for like comparison

This argument, advanced by academics, holds that testosterone is both NECESSARY and SUFFICIENT for performance. But this is false, nobody has or should ever suggested that it would be sufficient, only that it is necessary.

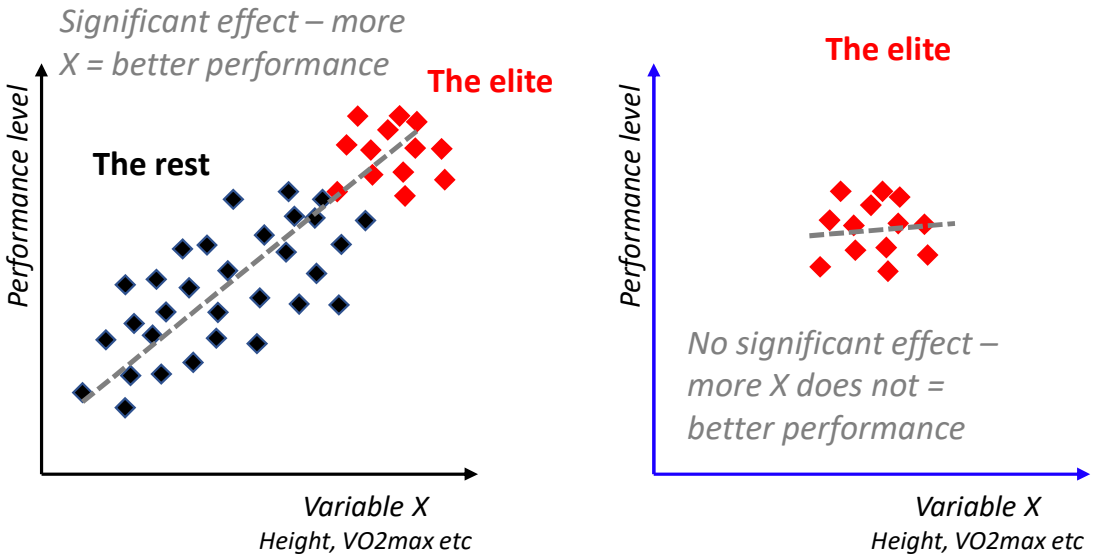
Consider the example of basketball and height. Key question: Does height matter for basketball performance?

Nobody should disagree that height has a significant impact on basketball performance. To the extent that those who lack height (short people) will be exceptionally rare at the very highest level of basketball (the NBA and WNBA)

Yet, if we took a group of 300 NBA players, we would NOT find a significant relationship between basketball performance and height. The tallest players in the NBA are not necessarily the best. Does this disprove that height matters to basketball performance? *(the same is true for VO2max and performance in marathons)*

WHY?

Illustration of the "Karkazis/Ivy fallacy"



In the whole world

In a narrow elite population

What is happening here?

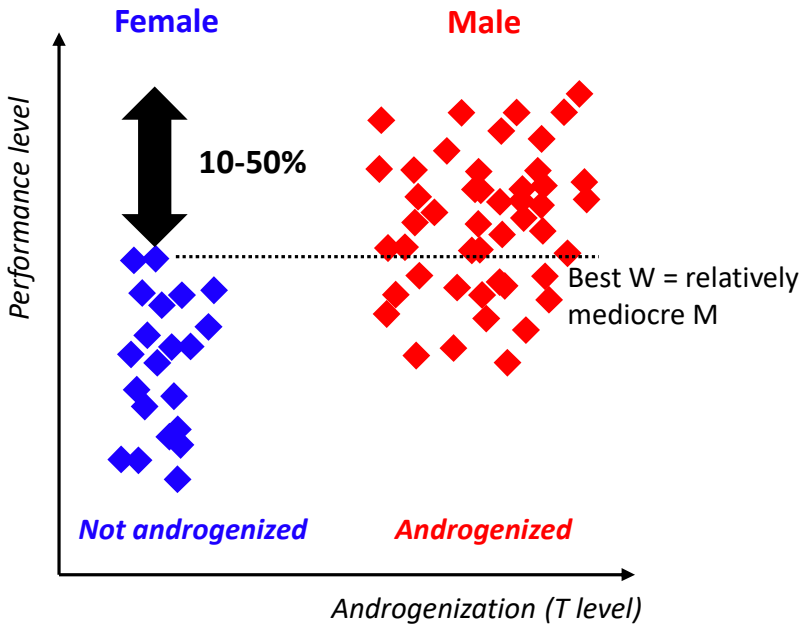
As soon as we consider an elite population, the predictive power of Variable X on performance disappears. Why?

Because within this population, THEY ALL ALREADY HAVE X.

Eg: In the NBA, they **all have a requisite height**. In marathons, they **all have the requisite high VO2max** (relative to the whole population).

Then the impact of the variable diminishes. But this does not make the variable less important – it **was a requirement to become elite in the first place**

Application of accurate biology and logic to men's and women's sports



Key points:

1) The precise concentration of testosterone is a red herring. What matters is whether testosterone has had an effect on physiology during development. That is, has androgenization occurred? T is a proxy for this, BETWEEN groups, but not WITHIN
2) This is binary – it either has or it has not, and this breaks down along lines of either male T or female T levels during life. It has occurred in males, it has not occurred in females (with rare exceptions in certain DSDs, covered later)
3) Within male and within female, T level doesn't predict performance, because they're already androgenized (or not)
4) There is still overlap in performance, but the **point is not that the best women are matched with the average males**. It is that the best males are 10% to 50% better than the best females. Or that the typical/average male is 10% to 50% better than the typical/average female
5) Categories exist to prevent **male androgenization** from confounding performance in the **female category**

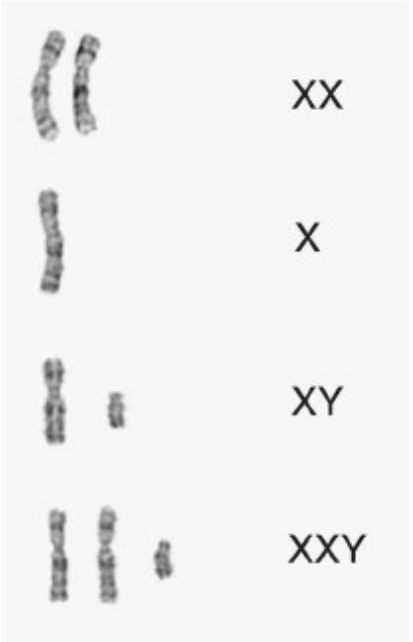
You need X (testosterone) to "get through door" in the group with male performance capacity. But once through the door and in the room, many other variables matter

The theory of Karkazis and Ivy should be rejected as a fundamental misunderstanding of biology, sports performance and category membership

Some people say that sex is more complex than male and female, that you get people who don't fit the binary. What about those people?

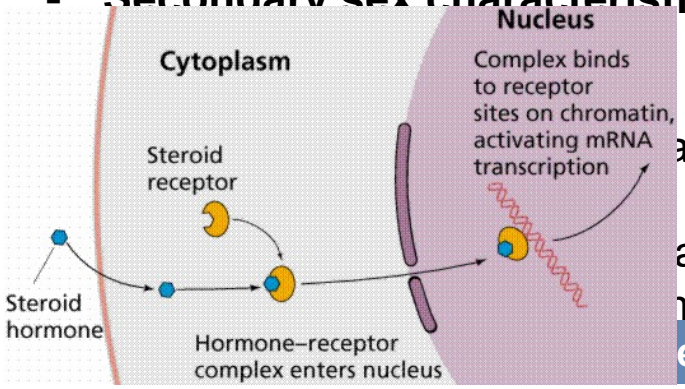
Chromosomal abnormalities

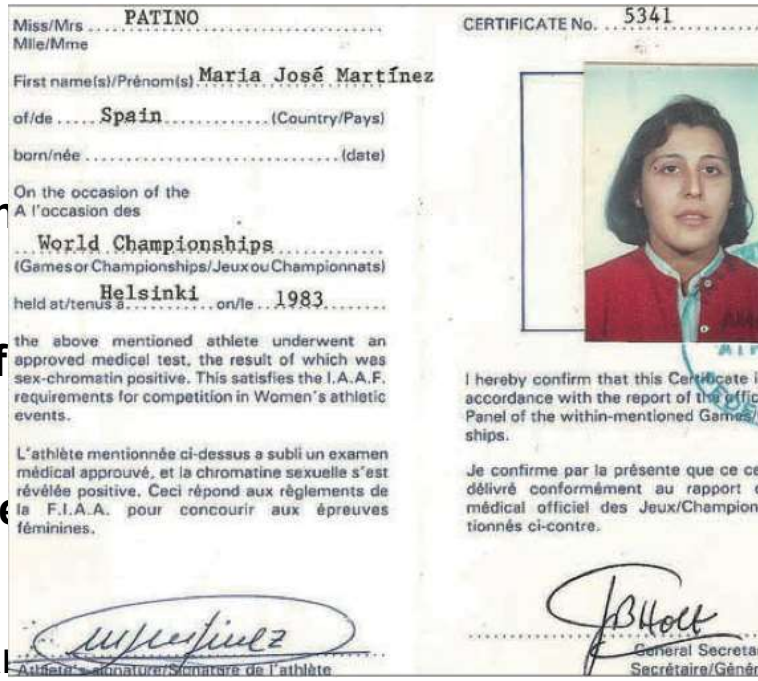
1. **Abnormal Sex Chromosome DSD**
   - **One X chromosome - Turners syndrome (females)**
   - **XXY - Klinefelter's syndrome (infertile males)**
   - **Mosaicism - XX cells and XXY cells**
   - **XX and XY cells or X and XY cells**
   - **Men with Klinefelter's (XXY) would be eligible to compete as females due to the presence of the Barr - potentially have an advantage.**
2. **Male Sex Chromosome DSD (female appearance)**
3. **Female Sex Chromosomes DSD ("male" characteristics)**



XY females - Insensitivity

- **Androgen Insensitivity Syndrome (AIS) is a cor**
  an XY-individual develops either completely or
  because they are INSENSITIVE to the effects of
  (testosterone)
- **Secondary sex characteristics and musculature**




Miss/Mrs PATINO
Mlle/Mme
CERTIFICATE No. 5341
First name(s)/Prénom(s) Maria José Martínez
of/de Spain (Country/Pays)
born/née (date)
On the occasion of the
A l'occasion des
World Championships
(Games or Championships/Jeux ou Championnats)
held at/tenus à Helsinki on/le 1983
the above mentioned athlete underwent an approved medical test, the result of which was sex-chromatin positive. This satisfies the I.A.A.F. requirements for competition in Women's athletic events.
L'athlète mentionnée ci-dessus a subi un examen médical approuvé, et la chromatine sexuelle s'est révélée positive. Ceci répond aux règlements de la F.I.A.A. pour concourir aux épreuves féminines.
I hereby confirm that this Certificate i
accordance with the report of the offic
Panel of the within-mentioned Games/
ships.
Je confirme par la présente que ce ce
délivré conformément au rapport
médical officiel des Jeux/Champion
tionnés ci-contre.
Athlete's signature/Signature de l'athlète
General Secreta
Secrétaire/Génér

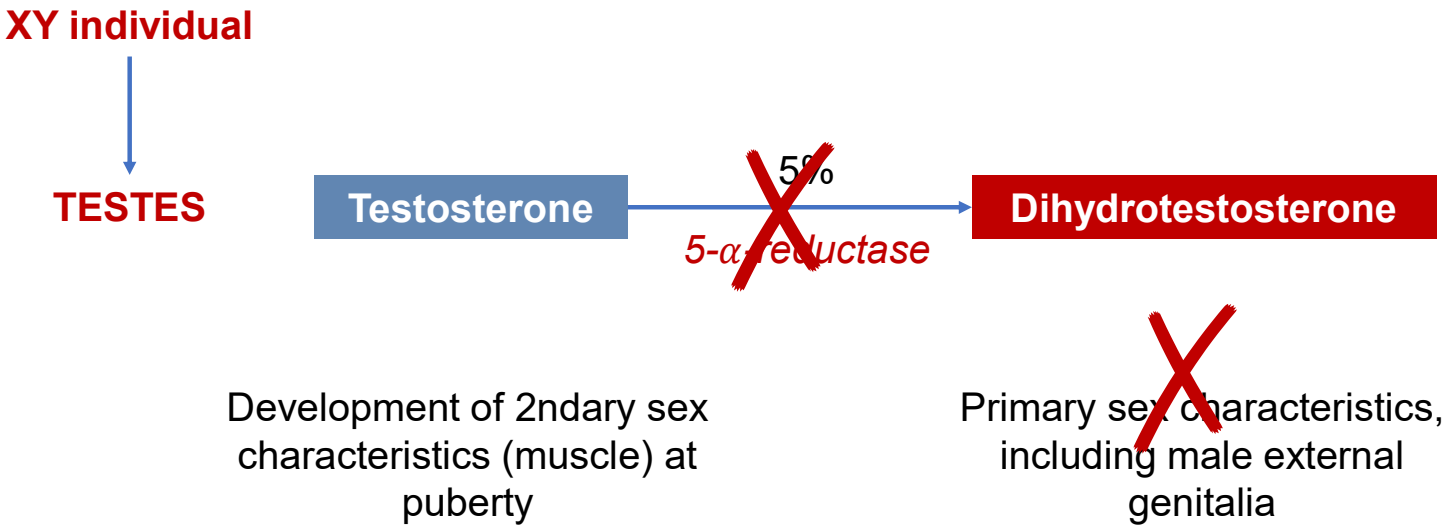
ar at puberty in human
of the reproductive system (primary)
apple, breast development, voice deepening
nass, bone structure/mass, anthropometry

e → **Primary and secondary sex characteristics**

Can be partial or complete

XY females: Synthesis

- **5-Alpha Reductase deficiency is a deficiency in an enzyme that converts testosterone into Dihydrotestosterone (DHT)**
- **DHT is an extremely potent androgen *('male')***



XX female masculinization

- **Congenital Adrenal Hyperplasia is a condition where the body can't produce cortisol & aldosterone**
- **Most commonly: enzyme deficiency (21-hydroxylase)**
- **Knock-on effect is hyper-activity of adrenal cortex & spill-over of accumulated steroid precursors to increase androgen production**
- **Individuals are XX, but masculinized**