World Rugby
Transgender policy group
25th February 2020

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Developmental biologist, University of Manchester, UK
Overview

to understand what sex is and how it develops

to understand how sex is relevant for sporting performance
Sexual reproduction

process by which all complex life reproduces itself
1.2bn year old phenomenon
parent packages half share of genetic information into a gamete
fusion of two gametes to create a new individual with full share
(+ genetic variation)
Sex

most species reproduce via two differently-sized gametes (anisogamy)

large gametes
FEMALE
eggs

small gametes
MALE
sperm

different gametes are made by different types of gonad tissue
Primary sex differentiation

what does “differentiation” mean?
changes in biochemistry/structure/function → specific cell types/tissue remodelling

gonad differentiation/7 weeks in utero
differentiation of bipotential gonads into testes (sperm production) or ovaries (egg production)

Primary sex determination

what does “determination” mean?
stable, restricted potential in the fate of cell
commonly used to describe indifferent/stem precursor → specialist cell

sex determination in humans
driven by genetics and determined at conception
sex chromosomes in humans are X and Y
SRY is a “master switch”; carried on Y chromosome

Primary sex differentiation

gonadal maturation is hormone-dependent
Leydig cells in testes $\rightarrow$ testosterone
Sertoli cells in testes $\rightarrow$ anti-Mullerian hormone
granulosa cells in ovaries $\rightarrow$ estrogen

Development of internal anatomy

Paired duct system/8 weeks in utero

**male internal genitalia**
epididymis, vas deferens, seminal vesicles

**Wolffian duct development**
Leydig cells in testes $\rightarrow$ testosterone

**Mullerian duct regression**
Sertoli cells in testes $\rightarrow$ anti-Mullerian hormone

**female internal genitalia**
Fallopian tubes, uterus, cervix, vagina

**Mullerian duct development**
Absence of anti-Mullerian hormone

**Wolffian duct regression**
Absence of testosterone

teachmeanatomy.info
Development of external anatomy

Bipotential/12 weeks in utero

local conversion of testosterone $\rightarrow$ dihydrotestosterone

male external genitalia
penis, scrotum

lack of dihydrotestosterone

female external genitalia
clitoris, labia

obgynkey.com
Sexual selection

different gamete size forces “arms races” between and within sexes

intersexual selection
between sexes
“choosing a mate”

intrasexual selection
within sexes
“competing for a mate”

humans: male as provider

humans: male as dominator
Sex dimorphism

human males, like males in most other species, are bigger and stronger than their female counterparts

secondary sex characteristics (non-reproductive traits) develop during puberty/10+ years

both sexes (e.g. growth hormone, IGF1)

increased height, increased bone density, acne, libido

males

superior height, superior bone density, superior muscul arity, facial/whole body hair, larynx enlargement

testosterone

females

pubic/underarm hair, breast growth, fat increase, widening of hips

estrogen
Sex dimorphism

males
-testosterone

females
-estrogen

Clark et al., Clin Endocrinol, 2019
The adult male hunter/fighter

**Skeletal**
- Bigger/longer bones
- Increased height/longer limbs/wider wing and handspan
- Higher bone density/thicker cortical area/wider vertebrae/thicker skulls
- Narrower pelvis/lower Q angle
- Lower elbow rotation

**Muscular**
- Larger fibres/more fibres/lower intramuscular fat/denser muscle/larger mass (40-60%)
- More myonuclei/muscle memory
- More fast-twitch fibres
- Tighter connective tissue

**Miscellaneous/unknown**
- Faster audiovisual response
- Heightened detection of fine movement
- Lack of menstruation or pregnancy
- 6500 differences in gene expression

**Cardiovascular**
- Larger hearts
- Larger lungs
- Higher haemoglobin levels
- Higher VO2max
Sex influences sporting performance

- Males are stronger
- Males can move faster
- Males can jump further
- Males can throw harder
- Males can kick harder
- Males can punch harder
An overview of performance gaps

- Lower body dominant
  - Females closer to male capacity

- Upper body dominant
  - Females further from male capacity
Disproportionate upper body strength

largest performance gaps observed in activities weighted for upper body strength

Total: 40-60% more muscle mass
Arms: 75% more muscle mass
Wider shoulders/chest with bigger muscles
90% greater upper body strength

Legs: 50% more muscle mass
65% greater lower body strength

throwing performance gap is a marker for the greater amount of force a male can put through his shoulder safety consideration for rugby (esp. increased height)

Lassek and Gaulin, 2009; Stoll, 2000; references therein
“Evolution built men to pack a punch”

Grip strength in general adult population

89% of males are stronger than 89% of females

US National Health and Nutrition Examination Survey (NHANES) 2011-2012

Non-athletic males have 2.6X more power than females in a punch motion

Non-athletic males have 2.6X more power than females in a punch motion

Sexual dimorphism in human arm power and force: implications for sexual selection on fighting ability
Jeremy S. Morris, Jenna Link, James C. Martin and David R. Carrier
Performance gaps in elite rugby players

10m sprint
1.68s vs 1.87s/10.2%
Small overlap between slowest males and fastest females

Bench press 1 rep max
135kg vs 75kg/44.4%/1.8X
No overlap between weakest males and strongest females
Hypothesis: a problem of scale?

is male superiority a function of increased size?

“if Flo-Jo were as big as Bolt, would she be as fast?”

Weightlifting
performance gap approximately 25% across all weight categories
maximum weight thresholds somewhat limit maximum height
can compare males and females by stature
Males are stronger than bigger females

Oxana Slivenko
69kg/1.64m
WR: 276kg

Liao Hui
69kg/1.68m
WR: 359kg

Hripsime Khurshudyan
90kg/1.73m
WR: 283kg

Tatiana Kashirina
108kg/1.77m
WR: 348kg

23.2%
21.2%
3.1%
When does the performance gap emerge?

Sports-relevant (secondary) sex characteristics that confer male advantage develop at puberty, under the influence of circulating testosterone evidenced by comparing female records/performances against schoolboys.

<table>
<thead>
<tr>
<th>Event</th>
<th>Schoolboy male record (age)</th>
<th>Elite female record</th>
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</thead>
<tbody>
<tr>
<td>100m</td>
<td>10.20s (15)</td>
<td>10.49s</td>
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<tr>
<td>800m</td>
<td>1m:51.23 (14)</td>
<td>1m:53.28s</td>
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<tr>
<td>1500m</td>
<td>3m:48.37s (14)</td>
<td>3m:50.07s</td>
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<td>Long jump</td>
<td>7.85m (15)</td>
<td>7.52m</td>
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<tr>
<td>Discus</td>
<td>77.68m (15)</td>
<td>76.80m</td>
</tr>
</tbody>
</table>

From world champions to humbling defeat against Under 15s side... World Cup-winning USA women's team suffer 5-2 loss against Dallas academy boys

- USA women’s team played warm up for Russia friendly against Dallas Under-15s
- Informal game did not go to plan for international side as they lost 5-2
- Result did not seem to matter with USA beating Russia 4-0 in main fixture
- Players’ spirits were still high after humbling loss as they posed for photos

By WILL GRIFFEE FOR MAILONLINE
PUBLISHED: 10:16, 7 April 2017 | UPDATED: 10:36, 7 April 2017

Australian women’s national team lose 7-0 to team of 15-year-old boys

JAMES BENCE | Thursday 26 May 2016 11:00 | 1 comment
Female rugby players vs boys

10m

<table>
<thead>
<tr>
<th>%ile</th>
<th>5th</th>
<th>10th</th>
<th>50th</th>
<th>90th</th>
<th>95th</th>
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</thead>
<tbody>
<tr>
<td>Elite males</td>
<td>1.82</td>
<td>1.77</td>
<td>1.68</td>
<td>1.58</td>
<td>1.56</td>
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<tr>
<td>Elite females</td>
<td>2.02</td>
<td>2.00</td>
<td>1.88</td>
<td>1.78</td>
<td>1.76</td>
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<tr>
<td>U18 males</td>
<td>2.11</td>
<td>2.06</td>
<td>1.90</td>
<td>1.80</td>
<td>1.76</td>
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</tbody>
</table>

Bench

<table>
<thead>
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<th>%ile</th>
<th>5th</th>
<th>10th</th>
<th>50th</th>
<th>90th</th>
<th>95th</th>
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</thead>
<tbody>
<tr>
<td>Elite males</td>
<td>108</td>
<td>115</td>
<td>140</td>
<td>155</td>
<td>160</td>
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<tr>
<td>Elite females</td>
<td>60</td>
<td>60</td>
<td>73</td>
<td>87</td>
<td>96</td>
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<tr>
<td>U18 males</td>
<td>58</td>
<td>60</td>
<td>75</td>
<td>77</td>
<td>88</td>
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</tbody>
</table>
Females need a protected sports category

a perspective on the male:female performance gap

track running/10.5%

Florence Griffith Joyner WR 10.49s/34.32kph

in 2019, 824 males ran 3347 100m races in equal/faster time

Habana
10.40s

Chavanga
10.27s

Isles
10.13s

Hill
10.19s

Djokovic
36.02kph

Rooney
34.47kph
Exceptions to male exclusion

disorders of sexual development
46, XY DSDs
not a monolith
e.g. complete androgen insensitivity syndrome vs 5-alpha reductase deficiency

<table>
<thead>
<tr>
<th>Feature</th>
<th>CAIS</th>
<th>5ARD</th>
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<tbody>
<tr>
<td>Gonads</td>
<td>Testes</td>
<td>Testes</td>
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<tr>
<td>Testosterone</td>
<td>Male levels</td>
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<tr>
<td>production</td>
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<tr>
<td>Testosterone</td>
<td>Absent</td>
<td>Present</td>
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<tr>
<td>response</td>
<td></td>
<td></td>
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<tr>
<td>Internal genitalia</td>
<td>Absent</td>
<td>Wolffian/male</td>
</tr>
<tr>
<td>Dihydrotestosterone</td>
<td>Absent</td>
<td>Absent</td>
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<tr>
<td>response</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External genitalia</td>
<td>Female</td>
<td>Feminised</td>
</tr>
</tbody>
</table>

necessary to regulate individually, based on assessment of performance impact
testes + testosterone production + testosterone response = performance advantage
Exceptions to male exclusion?

transitioning males
males who wish to be considered female
inclusion of transitioning males in female sports codified by IOC in 2003 and policy updated in 2015

1. declaration of female gender identity
2. testosterone <10nM for 12 months prior to during competition in female category
most sporting federations adopted a parallel stance for professional track/elite sport

widely touted as sufficient to remove the performance advantage conferred by male puberty

is it?
Required magnitudes of physiological change

**track sprinting**

Observation: the performance gap between males and females is 10%
Observation: males have 50% more muscle mass in legs
Observation: track sprinting requires massive lower leg input

**Assumption:** the 10% performance gap can be explained by the 50% difference in leg muscle mass

The performance gap reaches standard competitive gap with 25-30% decrease in muscle mass. Only Usain Bolt can keep up with FloJo if muscle mass loss is closer to 5%, gap remains at 8.5%.

700 males each year faster than FloJo
The challenge

“sport will have to meet those challenges by putting in place adequate rules in order to protect the integrity and fairness of sport competitions for women”
Arne Ljungqvist (IOC committee member), 2018

to include transitioning males within female sports categories, it must clearly demonstrated these males do not:

1. endanger the physical wellbeing of their competitors or teammates and compromise SAFETY

2. retain performance advantage from male puberty and compromise FAIRNESS

3. cause females to lose sporting opportunities and compromise INCLUSION