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Transgender Athlete Inclusion: A Scientific Review

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Transgender Inclusion

Executive Summary

Mandate and Scope

This report was commissioned with a mandate to review the scientific and grey literature regarding trans women athletes' participation in elite or otherwise high-performance sport (herein shortened to 'elite sport'), with a special focus on the state of scientific literature around the science of testosterone and whether there is evidence that past exposure to amounts of testosterone considered by the IOC and IAAF to be within the 'normal male range' confer athletic advantage to trans women elite athletes.

The report's scope is limited to (a) binary trans women (b) elite athletes (c) who have elected to undergo hormone suppression (d) post puberty, and is not directly applicable to other trans populations, other levels of sport, nor to other decisions regarding methods of gender affirmation.

There are competing ways of conceptualizing ("epistemologies") trans women's participation in elite sport which impact framing, research, and movements forward, which can be characterized in terms of where each locates and how each frames 'unfairness'. The first, an orientation already deeply imbued within current sport structures, locates unfairness in trans women's bodies and sees their transformation as the resolution; the other locates unfairness in the sport structures themselves and requires their transformation towards inclusion of embodied diversities as the resolution. This report includes both.

Methods

The findings of this report result from a thorough literature scan in May/June 2021. Academic (i.e., peer reviewed primary or synthesized secondary research journal articles) and grey (not peer reviewed, reports, policy documents, do not follow a scientific process) literature were included.

Inclusion Criteria:

- Published between **2011** and **2021**;
- English language;
- **Primary research** or **syntheses** (e.g., meta-analyses, reviews, etc.);
- **Grey literature** was included if it was a **final evaluation** or report on empirical data;
- **Grey literature** was included if it was about **rules currently in place** worldwide for the inclusion/exclusion of trans women in high-performance sport.

Excluded: discussion articles, opinion pieces, or commentaries not presenting empirical or theoretical research.

Key Biomedical Findings

1. Biological data are severely limited, and often methodologically flawed.

- Most studies do not adequately adjust for factors such as height or lean body mass;
- Almost no studies examining the effects of testosterone suppression on trans women do so among trained athletes;
- Most studies on the effects of testosterone on sport performance involve examination of individuals who use performance enhancing drugs;

2. There is limited evidence regarding the impact of testosterone suppression (through, for example, gender affirming hormone therapy or surgical gonad removal) on transgender women athlete's performance.

- Most of these studies had small sample sizes, imperfect measurement techniques, poor reference group comparisons, and studied a sedentary/non-athletic/untrained sample population;
- Some significant studies used misleading data sources and actively ignored contradictory evidence.

3. Available evidence indicates trans women who have undergone testosterone suppression have no clear biological advantages over cis women in elite sport.

- Most studies do not adequately adjust for factors such as height or lean body mass;
- Almost no studies examining the effects of testosterone suppression on trans women do so among trained athletes;
- Most studies on the effects of testosterone on sport performance involve examination of individuals who use performance enhancing drugs;

Key Sociocultural Findings

1. Biomedical studies are overvalued in sports policies in comparison to social sciences studies.

- The literature on trans sport policies, their implementation, people who write them and apply them, consequences for athletes, and the debates they frame is constitutive of the social hierarchy of knowledge, within which some sciences are discredited to the benefit of others;

- Excluding certain types of knowledge from the restricted definition of 'scientific' makes it possible for sport governing bodies to obscure the power relations at play in the creation, maintenance, and legitimization of regulations;
- There are troubling links between some researchers, sport organizations, and third organizations with anti-trans agenda;
- Some sport organizations use science strategically, drawing solely and uncritically on data which appears to support their claims;
- Only certain biomedical factors are policed under a mandate of 'fairness' in elite sport, despite strong evidence that financial material resources (such as access to infrastructure and equipment, nutrition, time to train, higher salaries) are associated with advantage in sport.

2. Policies that impact trans women's participation in elite sport are the continuation of a long history of exclusion of women from competitive sport – an exclusion that resulted in the introduction of a 'women's' category of sport in the first place.

- Since the early 20th century, elite sport policies worked to pathologize and control women's bodies and enforce dimorphic sex. There is, however, a significant overlap in all sexual characteristics. 'Male' and 'female' are not mutually exclusive categories and should not be treated as such;

- Many social factors continue to keep women's sport less valued than men's: fewer resources, lack of access to sport spaces or equipment, fewer coaches and teams, sexist discrimination, having to quit sports due to sexual violence, lesbophobia, classism, racism and/or transphobia;
- There are examples of competitive sport events that have changed sporting structures or put restrictions on particular athletes as women began to excel;
- The literature largely ignores areas where cis women have an athletic advantage over cis men (long distance swimming, for example), as well as the ways in which trans women's participation in elite sport elevates sport for all women.

3. Current trans "inclusion" sport policies use arbitrary bounds that are not evidence based.

- Elite sport federations often apply none, one, two, three, or more of the following criteria based mostly on their own perspectives/ideologies: gender declaration (gender marker, letter, or just during registration), stable gender identification of 2 years or 4 years, hormonal level (not specified, 5 nmol / L or 10 nmol / L), request for Therapeutic Use Exemption (TUE), physical and morphological criteria, medical file or medical appointment;
- Many sport organizations circulate myths about trans women that are transphobic, harmful, and violent. For example, that trans women will overwhelm women's sport, when trans women are in fact under-represented in sport and especially elite sport; or that trans women are cis men in women's clothes, a dangerous misunderstanding of trans women's identities and experiences directly linked to trans women's decreased safety especially in such highly gendered spaces as sport.

4. Cissexism, transphobia, transmisogyny and overlapping systems of oppression need to be recognized and addressed for trans women to participate in elite sport.

- Despite unavailability of the exact prevalence of trans women in the population, we can reliably conclude trans women are systematically underrepresented in elite athletics both in terms of participation and results;
- On a population level, trans women experience living conditions which are the result of downward social mobility and discrimination, including restricted access to and/or experiences of discrimination in vital spaces (i.e., housing, health care, work, public space including sports facilities, etc.);
- In qualitative studies, trans women have reported facing significant barriers to returning to sport after they transition;
- Trans women are not a monolith. Racism, classism, ableism, and overlapping systems of oppression must be addressed for trans women to be able to participate in elite sport. Trans women's diversity is also reflected in their transition journeys – diverse incomes, access, and desires affect in what medical gender affirmation processes a trans woman might participate and at what stage in her life course.

Conclusion

There is no firm basis available in evidence to indicate that trans women have a consistent and measurable overall performance benefit after 12 months of testosterone suppression. While an advantage in terms of LBM, CSA and strength may persist statistically after 12 months, there is no evidence that this translates to any performance advantage as compared to elite cis-women athletes of similar size and height. This is contrasted with other changes such as hemoglobin which normalize within the cis-women range within 4 months of starting testosterone suppression. For pre-suppression trans women it is currently unknown when during the first 12 months of suppression that any advantage may persist, which may justify the existence of policy for elite sports during this time period. The duration of any such advantage is likely highly dependent on the individual's pre-suppression LBM which in turn varies greatly and is highly impacted by societal factors and individual circumstance.

Any policy developed should carefully consider the current lack of participation of trans athletes - in many sport organizations, a complete absence, outright exclusion - and balance the value of fairness with inclusion. Policies should be crafted in ways which clarify and highlight administrators' duty to prevent and actively attend to barriers, carefully considering the administration of any such policy in ways which do not further discourage participation through the creation of unnecessary barriers, or unnecessarily infringe on the individual's privacy (including their right to not openly identify as transgender). Additionally, these individuals should not be excluded during any non-competition periods from participating with a team through training, exhibition matches or social activities.

Further research is needed to avoid arbitrary biological boundaries and ensure a foundation in sound evidence; a foundation which does not currently exist. Specifically, additional research is needed with sample populations of trained trans women and trained cis women as a comparison group, as current studies tend to focus on sedentary populations. These studies ought to include large populations, make comparisons with equivalent population groups (i.e., adjust for height and weight), and avoid using measures which are empirically proven to be unreliable outside of population-level analysis (i.e., handgrip strength).

Political, historical, sociocultural contexts must also be intentionally considered in implementation, the framing of ‘trans inclusion’ policies, defining ‘fairness’ in sport, and participation in the hierarchy of knowledge and scientific processes.

Introduction

The Canadian Centre for Ethics in Sport commissioned this literature review with a mandate to review the scientific and grey literature regarding trans women athletes' participation in elite or otherwise high-performance sport (herein shortened to 'elite sport'), with a special focus on the state of scientific literature around the science of testosterone and its impact on sport performance.

There is a triple bind for this research project: part of **the challenge of this review** is in responding to questions about the relationship between testosterone levels and athletic advantage while also accounting for scientific findings that risk reducing the question of trans women's inclusion in elite sport to one of (a) biology and (b) solely testosterone, while obscuring the highly relevant socio-historic-cultural contexts that render scientific and evidence-sharing processes vulnerable. While the current mandate understandably engages with discourse on trans women's participation in elite sport, this report features findings relating to both the mandated research question about testosterone and the assumptions layered in the discourses and framing of the mandated research question itself.

It is also important to emphasize the limits to the scope of this report before engaging with the findings: the findings of the current review should **not** be applied on community, recreational, school, or other levels/contexts of sport other than elite, where the evidence overwhelmingly supports the inclusion of cis and trans athletes of all genders. Nor does it review evidence regarding the full range of trans identities (i.e., transmasculine athletes, non-binary trans athletes, or the full range of transfeminine athletes) or athletes who transition at different stages of their life course (e.g. trans youth). The findings of this review are specific to trans women's participation in elite, high-performance sport and are not necessarily applicable to these alternate contexts or populations. For more specific research questions regarding non-elite contexts and the full range of trans identities in sport, different evidence ought to be pursued.

While outside the scope of the mandate from CCES, the authors provide their recommendations in Appendix A based on their interpretation of the evidence reviewed and their previous scholarship and athleticism.

Methods

The findings of this report result from an analysis and synthesis of the existing literature. Academic (i.e., peer reviewed primary or synthesized secondary research journal articles, scholarly book chapters, other materials that follow conventional scientific and peer review processes) and grey (not peer reviewed, reports, policy documents, do not follow a scientific process) literature were included.

Researchers studying trans identities and sport in Canada and internationally were consulted to build a list of key search terms and literature. Articles were also hand-searched to identify further relevant materials. This process took place in May 2021.

In order to be included, materials had to fit the following criteria:

- Published between 2011 and 2021;
- English language;
- Primary research or syntheses (e.g., meta-analyses, reviews, etc.);
- Grey literature was included if it was a final evaluation or report on empirical data;
- Grey literature was included if it was about rules actually in place worldwide for the inclusion/exclusion of trans women in high-performance sport.

Discussion articles, opinion pieces, or commentaries not presenting empirical or theoretical research were excluded.

Approximately 50 academic articles, books, and grey literature materials were identified. The researchers entered articles they reviewed into tables (see Appendix B). In addition to this initial yield, researchers conducted searches for further academic articles with regards to particular issues, claims, or arguments through consultations with leading scholars, previous work, and library searches. These articles are included in analysis and referenced, but not included on the expanded review tables in Appendix B.

At the same time, a university librarian conducted a systematic search in June 2021 (see Appendix C for summary of yield and databases). A scoping review process was unable to be fully completed due to time constraints, however, the authors intend to publish the full scoping review results in future. The authors reviewed abstracts of the biomedical yield of the systematic review (n=360) to ensure no major biomedical articles were missed. (In fact, the systematic search was refined and benefitted from the articles identified through the present search methodology.)

The Structure of This Report: Biological and Sociocultural Approaches to Knowledge Production

What is apparent through public discourse and supported through analysis of the reviewed research materials is that there are competing ways of conceptualizing ("epistemologies") trans women's participation in elite sport.

This report is therefore organized by two main conceptualizations. For the purposes of this report, they have been broadly characterized by the way 'fairness' in sport is understood. One conceptualization, shorthanded to a sociocultural perspective, understands 'fairness' in sport as a sociocultural, embodied phenomenon, wherein sport systems need to change to fully welcome the embodied diversities of humans. This conceptualization questions the control elite sports exerts over definitions of gender and the long, ongoing history of sexism, cissexism, transmisogyny, and other forms of systemic discrimination trans women athletes face. The other conceptualization, shorthanded to a biological perspective, focusses narrowly on 'fairness' as a practice and/or enforcement of biological parity and on testosterone in particular (though, the discourses seem to be evolving to all manner of biological phenomena, and without consensus about what form 'biological parity' might or should take). This biological perspective of fairness in elite sport requires trans women's bodies to conform to yet unidentified biological measures.

These conceptualizations and the research available in each differ in reliability and impact, with elite sport often prioritizing biological framing and studies over the sociocultural. They also apply differently to different populations of trans women and transfeminine people, who are not a monolith. Because of these competing epistemologies, questions about trans women's participation in elite sport are often reduced to the question of the impact of prior exposure to higher levels of testosterone on athletic performance. Throughout this report, however, the authors will show that there are more salient and more appropriate gaps in biological evidence to consider, and more salient sociocultural considerations towards trans women's inclusion in elite sport. Therefore, despite the mandate of the report to speak to the up-to-date science of the impact of prior exposure to higher levels of testosterone on trans women's athletic performance, it is important to speak to the research in each epistemology. This report offers findings from both, which are presented together, but not equated to each other.

Top 10 Key Findings

1.

Regulations on trans women's participation are built on misogynistic assumptions and perpetuate the medical history of sports organizations' surveillance of women's bodies.

2.

Myth of sexual dimorphism: The difference between 'male' and 'female' and the idea that those categories are mutually exclusive. This thought stems from a myth because there is actually a significant overlap in all sexual characteristics.

3. 

There are important correlation, analysis, comparator, and conclusion issues in original biomedical studies. For example, many studies consider cis men as relevant representations or comparators of trans women, which is a fundamental mistake. Most studies do not adequately adjust for factors such as height and lean body mass. Further, almost all studies examining the effects of testosterone suppression on trans women do not use trained athletes.

4. 

The understanding of testosterone is more complex than a simple direct link to sports performance. Circulating testosterone is only one part, but testosterone receptors and other biological features matter. There is ongoing debate about the distinction between naturally occurring and artificially altered levels of testosterone (in both directions – artificial increase or decrease).

5. 

There is no tangible biological evidence of a supposed physical advantage among trans women who have elected for testosterone suppression (through, for example, gender-affirming hormone therapy or surgical gonad removal). There is not sufficient evidence with regards to trans and cis women athlete populations about the role of testosterone, nor unanimous consensus on 'acceptable' levels of testosterone. There is no evidence currently existing on the measurable difference that testosterone has on lean muscle mass for active versus sedentary individuals (i.e., if there exists a different ceiling for muscle mass or an increased baseline). The limited evidence that does exist indicates that trans women lost any overall performance advantage during twelve months on HRT (for example, Roberts et al., 2020).

6. 

Social explanations are not considered. For example, the lack of material resources available for women's sport is constitutive of the differences in access to sport depending on gender that impact performance. Or, gendered representation of each sport impacts on the number of athletes participating in the sport and lower the competitiveness depending on the sporting category.

7. 

There is no consideration of the living material conditions of trans athletes. Trans people are subjected to discrimination in all aspects of their lives (housing, work, healthcare, social services, school, all public spaces, etc.). Those aspects are rarely taken into account in the literature.

8. 

Transphobia and transmisogyny are prominent in sport. Trans women are discriminated in access to sports spaces: Exclusion from taking part in sport, having to choose between continuing to play sport or transitioning, violence from opponents, supporters, and/or coaches, being outed, undergoing a humiliating medical examination, undergo sensationalist media treatment, etc.

9.

Only one type of potential physical advantage is policed (sexual characteristics in the women category). Those regulations affect already marginalized women athletes and do not engage in fair and equal redistribution of resources of all athletes to level the playing field.

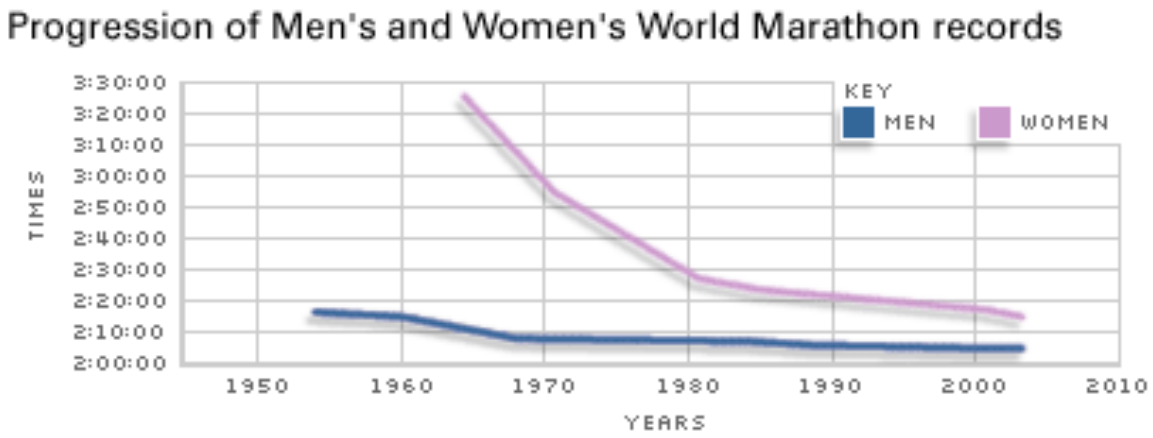
10.

There is no compelling foundation based on current research evidence – biological or sociocultural - for placing trans women into a third/transgender category of elite sport competition. It is important here to emphasize that the demand from non-binary communities for a third category could be legitimate, but what we are here contesting is the imposition of a third category onto trans women by governing bodies.

Biological Considerations

Biological data in this area are severely limited. In fact, an illuminating place to start is to note that, “to date, there have been no prospective studies investigating the changes in athletic performance in transgender athletes after hormonal transition” (Harper et al., 2021, p. 1), and many pertinent biological questions remained unexplored. The data that do exist often come with methodological concerns, and/or are limited in their ability to generalize onto elite transgender athletes. Many studies employ a false biological equivalency between the role of testosterone in doping to the role of testosterone among trans populations, including trans women. Most available studies do not include placebo controlled or blinded sample groups of trans women, cis women control groups, or even cis men control groups. Height and Lean Body Mass (LBM) are rarely adjusted for as a fair assessment would require. When adjusting for height and fat free mass, relative differences in strength between cis-men and cis-women largely disappear (Harms et al., 2011) making this a critical step in conducting population level comparisons. To illustrate this, the average 5’10’’ cis woman carries significantly higher muscle mass than a 5’4’’ cis woman. As we do not currently consider height to be an eligibility criterion (no threshold exists which would limit participation in sport), significant as in many men and women’s elite sport, participants tend to be taller than population averages. Unless sporting organizations put limits on height for competition, a fair comparison would use height adjusted cis-women (i.e. comparing the muscular mass and strength of a 5’10’’ trans women to a 5’10’’ cis women). Without this comparison, the standard of fairness would be set such trans women would be required to have lower LBM, strength and muscle mass than cis women of equivalent height. LBM is similarly useful as a measure, as it includes the total mass of muscles, bones, ligaments, tendons and essential fat. As Skeletal mass is an approximate function of height^2 and sex, height adjusted LBM can be used to compare total muscle mass the primary driver of performance. Similarly, these studies do not make adequate adjustments for other population level artifacts such as participation rates (known to reduce elite level performance levels), availability of training resources, social body image or other sociological artifacts that affect performance. A practical implication that illustrates this effect is the shrinking of the athletic performance gap between men and women as some of these socio-culturally-driven barriers are alleviated, as seen in Figure 1 below.

Figure 1 Progression of men's and women's world marathon records as reported in BBC Sport (14 April 2003).



Note: Reproduced from BBC Sport (14 April 2003).

The content of this report will demonstrate the irrelevance of the following finding to trans women's inclusion in sport; none-the-less, the report might be incomplete without it: the distribution of testosterone levels among elite athletes overlaps between cis men and cis women, with different exact hormonal profiles and descriptions of the overlaps across various sports described by Sonksen et al. (2018). While some women are considered to have high testosterone in the so-called male range, there are many elite male athletes with testosterone in the so-called normal female range. Bermon et al. (2014) additionally found that testosterone levels were not predictive of sporting success, with no demonstrated higher performance impact of testosterone among cis women track athletes (excluding confirmed or suspected athletes with doping violations and athletes Bermon et al. describe as 'DSD'). The following sub-sections outline the available research on testosterone, methodological concerns with research on testosterone in sport, and additional biological markers employed.

Sedentary Adults Versus Elite Athletes

As studies in this area rarely use trained athletic women as representative group, we must also give consideration to what differences exist in sedentary adults vs elite athletes, in particular how total muscle mass (which can be approximated from LBM) increases with physical activity. To start, labour markets have significant gender divides, particularly in jobs with high physical demand where men are far more likely to hold these positions such as construction or the military (Bureau of Labour Statistics (BLS), 2020). The Euro Barometer (2010, pp. 12) found youth (aged 15-24) participation in sport heavily favored men (71% male, 50% female) this gap extended for heavily active youth participating in sport at least five times a week (19% male vs 8% female). Further there are significant differences between genders for non-sedentary adults and trained athletes due to social pressures and sports preference. Findings also establish that type of sporting activities is highly gendered, where women seek physical activities that emphasize slimness, muscle tone and other standards of post-modern femininity (Pfister, 2011). This suggests that population level LBM, Cross Section Area (CSA) and strength are not representative of the athletic potential that cis women could achieve if these gendered social expectations did not exist. Not only do cis women have lower participation rates in physical activities which limit their muscle production, when they do participate in physical activities, they further de-emphasize the production of muscle mass by selecting roles which do not prioritize strength and muscle mass. This has been reported in dance where men tend towards mesomorphy (athletic and muscular body type) and females towards ectomorphy (thin, minimal muscle mass, low body fat; Ferrari et al., 2013). Notably, women dancers had significantly lower values for lean body mass, body fat percentage and overall lower BMI (Ferrari et al., 2013; Matthew et al., 2014). Similar differences in body compositions have been seen in elite athletes across many sports, going as far back as 1955 (Krawczyk et al., 1955). These sociological pressures result in cis-women having lower LBM and strength than their biological potential would allow for.

It is important to note that participation rates also dramatically impact likely performance of elite athletes. This is due to statistical artifacts whereby the larger a study population, the more likely outliers will develop to maximally perform a task. There also were no studies that examine areas that as a population cis-women outperform cis-men. These areas include women having higher levels of endurance and quicker recovery as a result of higher proportion of type 1 muscle fibers (Haizlip. et al., 2015) Increased glycogen sparing fat oxidation during endurance exercise (Tarnopolsky, 2008), higher myocardial perfusion, extracellular volume and myocardial perfusion stress (Nickander et al., 2020), and at a population level of untrained individuals' higher performance in balance (Torres et al., 2014). It should not be

assumed that men outperform women in all elite sports. This fact is currently not considered in any of the research examining trans populations in elite sport.

Along with using sedentary adults as proxies for elite athletes, these studies also tend to have very small sample sizes, regularly use imperfect measurement techniques, measure sex differences that are poor proxies for performance and use inappropriate reference group comparisons to establish their conclusions, all of which limits the applicability of the research for policymaking. More concerning, there exists significant evidence that some highly impactful articles in this area selectively included, manipulated or used misleading data sources to create support for their conclusions while ignoring all evidence that contradicted these conclusions. Specifically, Hilton and Lundberg (2020) have written what is best described as an argumentative essay in the form of original scientific research (see Appendix D for detailed methodological concerns).

Population Level Comparison Groups

Research investigating the potential for athletic advantage conferred onto transgender athletes tends to be centered on relative changes to LBM, CSA, strength and hemoglobin as a result of testosterone suppression. In this it is important to note that no one biological marker can be used as a proxy for the complex set of advantages and disadvantages that is attributed to individual performance. As a result, bodies (both cis and trans) must be looked at in a holistic way, and that their performance is a result of many interactive systems social and biological and not just the sum of discrete biological components. We must also examine what bias we have when examining biologic advantage especially as it relates to transgender women. In sports, athletes are regularly praised as talented for having physical attributes which gain them significant athletic advantage compared to population averages. An example of this is with Michael Phelps who notably is reported to have a longer torso, shorter legs, hyperextended joints, double jointed elbows and ankles, size 14 feet and he produces less lactic acid than other athletes. All of these attributes create a significant performance advantage, yet his biological advantages are not considered unfair. Rather than examining individual variations of LBM, CSA, strength and hemoglobin, we should instead examine the total impact of Hormone Replacement Therapy (HRT) on an athlete's performance. In this, we should also note that outside of sports with defined weight categories, weight and height are not considered to be an unfair advantage, rather taking positions as examples of tolerable unfairness (Devine, 2018). This is despite height being highly predictive of not just lean body mass, but also in measuring maximal torque. The increased lever length attributed to skeletal frame (height) accounts for significant levels of the variation measured for both men and women

(Harbo et al., 2011). It is important to note that both male and female muscle mass are the same strength when comparing equivalent cross section size or mass (Costill et al., 1976) and total mass and cross section size both increase with height for both cis-men and cis-women (Forbes, 1974). When adjusting for height and weight, cis-men still have higher LBM than cis-women, largely as a result of being able to achieve a lower body fat percentage, a direct performance advantage due to having less non-contractile tissue to carry. It is unsafe for cis-women to attempt to achieve cis-men levels of body fat (Nazem & Ackerman, 2012). Despite this, we could find no studies that examined the effect of HRT on body fat percentage or performance. This is despite the fact that widely used part of HRT is estrogen supplementation which impacts body fat retention (Handelsman et al., 2018).

Population Differences

Many studies in this area often use cis men as a reference group to trans women. This is highly flawed, as the typical pre-medical transition woman does not exhibit a body that is comparable to that of a cis man. These flawed assumptions lead to an under reporting of the effect of testosterone suppression in individuals who were assigned male at birth due to a lower starting muscle mass pre-suppression.

Table 1 below illustrates the average height and weight of trans women participants.

Table 1 Average height and weight of trans women participants.

Article	Height (cm)	Weight (Kg)	Country	Trans Women Participants (n)
Wiik et al., (2019)	180	73	Sweden	11
Defrayne et al., (2018)	179	72.8	Netherlands and Belgium	239
Gava et al., (2016)	180	73.0	Italy	40

Table 2 Height and weight among cis men and cis women (as presented by Harper, 2020).

Country	Height(cm)/Weight (Kg) (cis men)	Height(cm)/Weight (Kg) (cis women)
Sweden	180/86.8	166/70
Netherlands	183/87.4	169/72.3
Belgium	181/87.8	165/70.0
Italy	177/83.6	166/70.0

Note: Reproduced from Harper (2020).

The data in Tables 1 and 2 show that pre-testosterone suppression trans women cannot be compared to cis men (while closer to cis men for height, weight is lower and seemingly closer to cis women's). It may follow that trans women as a population have lower BMI than cis women, and therefore lower height adjusted muscle mass than cis women. This is important to note as the majority of studies examining the effect of testosterone suppression in trans women assume that their starting muscle mass is equivalent to cis men.

This finding is also supported by cross section studies measuring the baseline differences between pre-testosterone suppression trans women and cis men. These data clearly show that it is erroneous to assume trans women and cis men are synonymous. Therefore, in order to examine if any advantage exists, we must compare the observed reduction in LBM, CSA and strength with height adjusted cis women and not cis men. This is largely not done in the available literature and leads to misleading conclusions of any retained advantage. An equivalent facetious argument using height would be that the average child grows 70cm by the age of 18 but the average adolescent only grows 30cm at the age of 18, therefore children who have turned 18 have an unfair advantage due to a 40cm height gap. Table 3 below shows the relative change between pre-suppression transwomen and post-suppression transwomen, both of whom have lower LBM, CSA and strength than cis-men.

Table 3 Relative changes between pre- and post-suppression trans women among various markers.

Category	Difference
LBM	6.4% (Van Caenegem et al., 2015), 17.2% (Lapauw et al., 2008) 8.0% (Haraldsen et al., 2007)
CSA	6.0% (Van Caenegem et al., 2015), 11.4% (Van Caenegem et al., 2015)
Handgrip strength	14.3% (Van Caenegem et al., 2015)

Neither of these options provides a robust framework by which trans athletes' performance should be assessed. Without making appropriate adjustments in height and LBM, and without consideration of other performance advantages or disadvantages, the standard set for fairness would require trans women to underperform or be at a demonstratable disadvantage compared to cis women. There must therefore be critical examination of the few existing studies that examine the direct impact on trans athlete's performance as a result of testosterone suppression through either Hormone Replacement Therapy (HRT) or surgical gonad removal.

Erroneous Information and Flawed Measurement Techniques

Several studies allude to performance advantages which are derived from testosterone exposure during key periods of development (i.e. puberty). However, while these advantages - such as Q angle, lung size and bone density - are commonly thought to confer a performance advantage, there is no support in the literature that these factors confer any such advantage. The Q angle - defined as the angle between a line drawn from the anterior superior iliac spine (ASIS) to the center of the Patella and a second line from the Patella to the Tibial Tubercle and has often been assumed to play a role in generating power during acceleration and efficiency of a running stride. However, under investigation there appears to be no performance advantage conferred in sport as a result of Q angle, further increased risk of injury attributed to Q angle can be entirely removed with training (Bruton et al., 2013; Kernozek & Greer, 1993; Thomas et al., 1998; Nguyen et al., 2009; Sigward & Powers, 2006; Hertel & Braham, 2004). Arguments based on bone density derive from systematically racist arguments first introduced in the 1920's while attempting to ignore this background, black women and women of color have higher bone density than white men (Leslie, 2012) removing any potential for bone density to be considered a factor for unfairness in trans athletes. Lung size is also commonly attributed as performance enhancing; however, it is never adjusted for height (taller individuals naturally have larger lungs on average) nor is it a good predictor of sport performance (Hopkins et al., 2018; Degens et al., 2019; Åstrand et al., 1964). To clarify, on the topic of Maximum Breathing Capacity (MBC) "MBC is not likely to be an adequate physiological measure of the competence of the respiratory system in strenuous work and should be regarded rather as the biomechanical limit of the possibilities of the ventilatory apparatus" (Breslav et al., 2000, pp. 485) and "After differences in lung volume are accounted for there is no intrinsic sex difference in the DLco, Vc, or Dm response to exercise … together, these data suggest that the pulmonary capillary blood volume response is proportional to lung size and is adequate to meet individual oxygen demand during exercise" (Bouwsema et al., 2017). As such, lung size should not be used as a proxy for an individual's endurance capacity.

Beyond using misleading physiological traits, studies often use measurement techniques with poor accuracy and generalizability. Hand grip strength, for example, is often used for broad population level analysis, however handgrip strength should not be used as a proxy for overall muscle strength (Yeung et al., 2018). In fact, due to ease of gripping the testing device, grip strength is largely correlated with hand size and therefore height (Alahmari et al., 2019). Additionally, some studies do not include cis female control groups, which leads to poor accuracy and confounding attributions. One example of this can be found in Wiik et al., (2020)'s study, in which the authors' results

ignore that cis women are also able to maintain or increase muscle mass while undergoing intense training cycles and that untrained females have a high capacity to build muscle mass, particularly upper body strength (Roberts et al., 2020). Without a cis women comparison group, the results are misleading. Moreover, many strength studies ignore that untrained individuals can quickly gain strength independent of muscle gain due to neural mechanisms (Chilibeck et al., 1997). This ability to quickly gain muscle is in addition to higher performance on strength tests that can be attributed to comfort and familiarity with testing devices after repeated use. As such, sedentary adults should not be used as a proxy for elite athletes when determining the ability to gain or retain muscle mass. Additional studies need to be made which appropriately control for these factors. This requires studies to use appropriate control groups of height adjusted elite athletes and measure muscle and strength from appropriate tests which can be used as a proxy for overall strength and adequately control for artifacts such as training familiarity and neural adaptations which give inaccurate measurement results.

Testosterone Effects on the Body

The general effects of testosterone on the body presented below must be further explored and ought be taken as guideposts rather than definitive. Many methodologies in these research projects relied on treating serum testosterone levels and doping as similar functions, but current science demonstrates that doping is not the same as serum testosterone levels. We present these effects below, however, to share a sense of the possible guideposts to explore and on which additional research is based.

Table 4 below summarizes the evidence on the generalized effects of testosterone on the body.

Table 4 Summary of evidence of the generalized effects of testosterone on the body.

Effect	Supporting Citation(s)
Increases muscle fiber diameter by increasing muscle protein synthesis	Griggs et al., 1989
Increases cardiac muscle	Thum & Borlak, 2002
Induces red blood cell production	Bachman et al., 2014
Increases height during puberty	Bourguignon et al., 1986
Bone formation is affected	Tuck & Francis, 2009

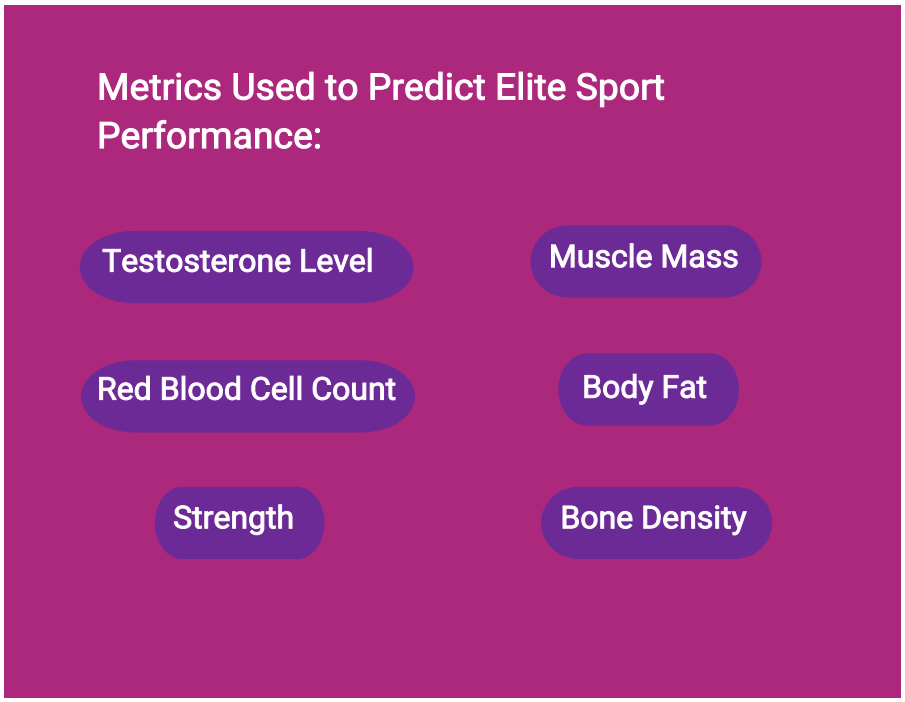
It is important to note that for some of these traits there is little or no research evidence that effectively and directly links them to athletic performance, and some of these references are notably older. Many of these claims come as a result of directly

comparing male and female sports performance, which has many notable flaws (as previously discussed). Many of the claims about the benefits of testosterone in athletics have gone unchecked since they are often taken for granted in biological research papers and do not include citations. For the sake of this report and providing a review of the most up-to-date evidence on testosterone, we entertained the presumptions - which many researchers have taken for granted without sufficient evidence - that there are links to performance to explore, despite the 'taken-for-granted', unsubstantiated, and refuted natures of this claim.

Effects of Testosterone Suppression for Trans Women

As we are examining elite athletes and the maximum potential of the human body, we must examine the extreme test case. That is an individual whose body is indistinguishable from an elite male athlete prior to testosterone suppression/estradiol supplementation and hypothesize what performance effects this individual would undergo as a result of HRT. This is the case scenario that policy is considering, as many trans women have lower muscular mass and strength than elite female athletes. In order to make this determination, we must look at the available evidence while considering if the research is making effective comparisons through:

1. Comparing trained athlete cohorts.
2. Including body composition (fat-free mass %) – affected by testosterone.
3. Using height-matched control groups.
4. Comparing participation rates between populations.



Athletes should be looked at holistically, that they are a sum of all their advantages and disadvantages which result in performance.

Additional possible metrics of performance could include direct LBM (Lean Body Mass) measurement through a dexa MRI scan.

It is important to note that no one metric can be used to predict performance. Further, the metrics reported do not account for the population level-differences that exist between trans women and cis men. Therefore, we must look at the absolute height adjusted values and compare these values with values produced by cis women. In this, athletes should be looked at holistically, that they are a sum of all their advantages and disadvantages which results in performance. Existing studies often do not continuously measure muscle mass during the 12 months of testosterone suppression, nor do they continue after the 12 months suppression to see if any persisting trend exists. This is significant for policy creation as a 12-month testosterone suppression requirement may be excessive to achieve practical performance equivalence. This also holds true for studies examining hemoglobin and red blood cell count where levels normalize within 4 months (See Table X). As a result, it is impossible to say exactly when any potential individual athletes' performance advantage has been mitigated. It is likely that the majority of any advantage is erased prior to the 12-month arbitrary timeline. In addition, flawed conclusions are often drawn from these studies as they notably ignore any significant disadvantages that affect trans women during and after testosterone suppression. These disadvantages can include: the diuretic effects of suppressive meds, speed, endurance or recovery as a result of reduced muscle mass while maintaining a larger body along with reduced aerobic capacity as well as sociological disadvantages. When examining the normal distribution of LBM, CSA and strength for cis-women (Jassen et al., 2000) sedentary trans-women appear to be well within the normal distribution of ciswomen which is suggestive that no residual effect on these traits exist once variations in height, weight, participation rates and social factors are accounted for. Additionally, it has been reported that for trans women who have undergone gonadal removal, their serum testosterone levels can often be below that of pre-menopausal cis women leading to additional performance and health factors (Genel, 2016). However, the majority of studies reviewed examine the effects of testosterone suppression on non-athlete trans women and have reported decreases in hemoglobin levels, lean body mass (LBM), muscle cross sectional area (CSA), and strength loss (see tables 5 - 8). Of particular note, hemoglobin levels after testosterone suppression achieve cis-female levels within 4 months (see Table 5 examining non athletes HCT or HG variance).

Table 5 Hemoglobin levels after testosterone suppression.

Article (by date)	Suppression effect	Time Frame	Participants (n)
Wiik et al., (2020)	10.5%	4 months	9
Wiik et al., (2020)	11.7%	12 months	10
Defrayne et al., (2018)	8.9%	3 months	239

Defrayne et al., (2018)	8.7%	6 months	239
Defrayne et al., (2018)	9.6%	24 months	239
Olson-K (2018)	8.3%	24 months	23
Vita (2018)	10.5%	6-30 months	21
Auer (2016)	5.5%	12 months	20
Wierchx (2014)	7.0%/4.6% *	12 months	52

*oral oestrogen vs transdermal oestrogen

Table 6 Muscle loss in non-athletes using LBM.

Article (by date)	Suppression effect	Time Frame	Participants (n)
Klaver (2018)	3.0%	12 months	179
Tack (2018)	4.7%	12 months	21
Gava et al., (2016)	3.5%	12 months	40
Auer (2018)	3.4%	12 months	45
Wierckx (2014)	5.4%/4.6% *	12 months	52
Van Caenegem (2014)	4.0%	12 months	49
Mueller (2011)	4.0%	12 months	84
Haroldsen et al. (2007)	4.0%	12 months	12

*oral oestrogen vs transdermal oestrogen

Table 7 Reduction in muscle CSA in non-athletes.

Article (by date)	Suppression Effect	Time Frame	Participants (n)
Wiik et al., (2019)	4.2% - quadricep	12 months	11
Tack et al., (2018)	8.9% calf, 4.1% forearm	12 months	21
Van Caenegem (2015)	8.6% forearm 4.4% Tibia	12 months	49
Gooren (2004)	9.5% - quadricep	12 months	19
Elbers et al., (1999)	9.5% - Thigh	12 months	20
Elbers et al., (1999)	11.7% - Thigh	36 months	20
Lapauw et al (2008)	23.9% forearm 24.1% tibia	48 months	69

Van Caenegem (2015)	11.4% forearm 6.0% tibia	Baseline	98

Table 8 Strength losses in non-athletes.

Article (by date)	Suppression Effect	Time Frame	Participants (n)
Wiik et al., (2019)	0% quadriceps	12 months	11
Scharff (2019)	4.5% handgrip	12 months	249
Auer (2016)	0% handrip	12 months	20
Van C (2015)	7.1% handgrip	12 months	49

Direct evaluation of performance is currently the most reliable method of assessing the impact of testosterone reduction on athletic ability, which in turn is used as a basis for fairness. However, limited evidence currently exists in this area. Harper (2015) used 200 self-reported race times from 8 trans women runners. Runners were at least 10% slower after transition and achieved World Masters Athletics (WMA) age-grade equivalence before and after transition. Similarly, Roberts et al., (2021) used one-minute maximal pushup count from a standardized army fitness test to determine the effect of medical transition on strength. This type of activity is critical to understand how performance is impacted not only by upper body strength, but also muscular endurance, cardio endurance and technique. Through this study they saw that trans women lost all performance advantage during twelve months on HRT, making it highly indicative of the impact on performance in sports where strength is but one component that is required for success.

Harper (2020) presented additional preliminary evidence (Table 9) that comes from ongoing research on the topic of retrospective performance declines of athletes after medical transition.

Table 9 Retrospective evidence from trans-athletes, preliminary data presented by Harper (2020).

Trans woman sprinter (100m)			
Race Times	Age	Athletic Gender	Age Group Percentile
10.95	31	male	89.4%
12.54	39	female	86.6%
Trans Women Cyclist			
Power Output	Age	Athletic Gender	

338	32	male	
300	36	female	
Trans Woman Rower (2km)			
Race Time	Age	Athletic gender	
7:01	18	Male	
7:25	20	Female	

Note: Reproduced from Harper, 2020.

This evidence is highly suggestive that any potential performance advantage is negated through effective testosterone suppression. Additional studies led by Joanna Harper are currently underway prospectively examining the impact of HRT on performance. It is important to note that some organizations have claimed safety as a value which may merit the discrimination of trans athletes. However, this appears to be an illogical position given the performance data. If there exists no policy regulating height and weight of athletes, and no performance advantage exists in terms of strength, LBM, CSA, or hemoglobin, then no basis exists for a safety concern. There currently exists no studies which examine transgender athletes posing a realized or potential safety risk to cis women in sport. The only available comparisons use population data for measuring potential impacts of cis men against cis women. As mentioned above, this should not be considered an equivalent comparison.

Evidence of Other Biological Markers

There seems to be agreement among biologically-based studies that we do not have the appropriate data or research to make evidence-based recommendations or decisions. Hamilton et al. (2021) suggest that, in absence of the research needed to make informed decisions, testosterone is an imperfect but most actionable proxy. This latter point is not consensual. There are many biological markers used in studies that are inadequate as biomarkers. There are also some additional biomarkers that may show promise if taken into account, all described in Table 10 below ('Levels of evidence for biological markers'). It is important to re-emphasize here that bodies are systems, and there is not one discrete biomarker that allows easy comparison of athletes' bodies to each other in terms of performance.

Table 10 Level of evidence for biological markers.

Biological Marker	Notes	References	Used As Marker In
Hand grip strength	Not a reliable biological proxy; more related to hand size than gender	Yeung et al., 2018; Alahmari et al., 2019	Yeung et al., 2018; Alahmari et al., 2019
Muscle mass	A potentially reliable biological proxy, but must be controlled for height and weight.	Dual energy X-ray absorption (DEXA or DXA) is considered a reference standard for muscle mass measurement (Buckinx et al., 2018), though evaluation of the technology seems mostly centred on diagnosis and care for sarcopenia. The technology has yet to be evaluated in studies of gender and athleticism.	Several studies used muscle mass as a biomarker, with significant methodological/analytical concerns.
Testosterone receptors	Ought be considered/measured along with testosterone levels, if pursuing testosterone as a marker.	As far as our research can tell, there exists no non-invasive, cost-effective way of determining the level of testosterone reception in an individual, but some studies mention receptor measurement might be a helpful/complementary.	None found.
Osteology – Q-angle	Not reliable biological proxy; more related to height.	Grelsamer, Dubey & Weinstein, 2005	Sutherland, Wassersug, & Rosenberg, 2017
Osteology – Bone density	Not reliable biological proxy; not related only to sex/gender but also link socio-	Fausto-Sterling, 2005 Ritz, 2017 : 321	Sutherland, Wassersug, & Rosenberg, 2017

	economic position. Can't be understood as strictly sex dimorphic.		
Red Blood Cell Count	Affects endurance and recovery	(See Table 5)	

> **Bodies are systems, and there is not one discrete biomarker that allows easy comparison of athletes' bodies to each other in terms of performance.**

Through examining the available literature, we have significant confidence with the following statements:

1. There is no clear scientific evidence that high levels of naturally produced serum testosterone was predictive of athletic performance among cis women.

2. Female participation in elite athletics is significantly lower than male participation. This leads to a significant statistical artifact in performance data where statistical sampling results in a larger gap in performance than would otherwise exist if participation rates between sexes were equal. This issue is compounded by training advantage conferred by additional resources typically given to male programs over female programs.

3. Women with high serum testosterone levels well above the expected range of cis-women as a result of natural variations in their sex-linked development (referred to also as 'DSD', 'Difference of Sexual Development', or 'Disorder of Sexual Development' - terms rejected by many in the intersex community as pathologizing) are overrepresented in some athletic events. However, selection bias may account for much of this discrepancy, as well as the global variation in responses to women with high testosterone (i.e., in the Global North the number of women in the broader population who could present with high testosterone is artificially suppressed because of

aggressive medical responses to children with intersex variation).

4. The higher levels of red blood cell count experienced by cis men is removed within the first four months of testosterone suppression. This suggests a rapid decrease in athletic performance particularly in sports with an endurance requirement.

5. There is no basis for athletic advantage conferred by bone size or density, other than advantages achieved through height. Elite athletes tend to have higher than average height across genders, there is overlap in height distributions among genders, and this is not currently considered an athletic advantage.

6. Trans women who are pre-testosterone suppression still have lower Lean Body Mass (LBM), Cross Section Area (CSA), and strength than cis males. This indicates that the performance benefit experienced by these individuals cannot be generalized by examining cis male athletes.

7. Non-athletic trans women experience significant reduction in LBM, CSA, and strength loss within 12 months of hormonal suppression. It is important to note that this 12-month threshold is arbitrarily defined, and no significant studies examine the rate of LBM, CSA or strength reduction over time.

8. When adjusting for height and fat mass, LBM, CSA and strength after 12 months of testosterone suppression, trans women still retained statistically higher levels than sedentary cis-women. However, this difference is well within the normal distribution of LBM, CSA and strength for cis-women (Jassen et al., 2000)

9. LBM, CSA and strength loss continues after the 12-month initial testosterone suppression.

10. Evidence directly examining the effect of testosterone suppression as it directly affected trans women's athletic performance showed no athletic advantage exists after one year of testosterone suppression (Harper, 2015, 2021).

11. Despite unavailability of the exact prevalence of trans women in the population, we can reliably conclude trans women are systematically underrepresented in elite athletics both in terms of participation and results.

12. Post gonadal removal, many trans women experience testosterone levels far below that of pre-menopausal cis-women.

13. That the literature largely ignores areas where cis-women have an athletic advantage over cis-men.

14. Estradiol likely plays a role in athletic performance as trans women undergoing HRT increase their average body fat percentage (Handelsman et al., 2018). This in turn reduces performance through increasing body mass for the equivalent LBM.

Sociocultural Context and Framing of Trans Women's Sport Participation

The evidence reviewed in this section provides clear indication that the questions (cis) sportspeople have about trans women competing in elite sport and policies that govern trans women's participation in elite sport policies are founded in transmisogynist, misogynoir, racist, geopolitical cultural norms. The literature reviewed here can provide excellent foundation for forward movement with regards to trans women competing in elite sport, help differentiate claims from empirical evidence, and help guide policymakers in building safe and inclusive competitive sporting environments.

It is worth noting that trans women athletes are a distinct group from intersex athletes. In elite sport, these groups are often combined together because each of their existences is seen in elite sport as a challenge to the misogynist, transphobic, sexist beliefs sports administrators enact in gender policies. Sports administrators' drives for what they frame as some kind of biological parity affect both these athlete populations and act to forcibly exclude them from competition, locating 'fairness' in women's and intersex peoples' bodies. In this section, the authors review literature which instead locates 'fairness' in unjust systems within sport. Therefore, while the authors focus on the impacts on trans women athletes, some factors in this section may also have bearing on intersex athletes' participation.

History of Gender Categorization in Elite Sport

A brief history of gender categorization policies and ongoing evolutions in elite sport is catalogued below. This timeline and the experiences of trans athletes are provided to illustrate the thinking around gender in elite sport as well as some experiences of athletes who lived through these policies. The long history of gender policies in elite sport is often used uncritically as reasoning that questioning transgender athletes' participation in elite sport is a natural, neutral part of longstanding questions of gender and gender categorization, but there is a rich body of literature on the racist, sexist, eugenicist, geopolitical origins and ongoing evolutions of such policies that provides relevant context.

> **1930's** - Muscle Moll - (see Cahn, 1993)
>
> **1936** – 100 meter sweep (intersex athletes) and Heinrich Ratjen
>
> **1937** IAAF Gender Protest Policy
> **1946** IAAF Medical Certificate
> **1948** ICO Medical Certificate
> **1966** European Athletics Championship – "Nude parades" / morphological and gynecological examination
> **1967** European Athletics Championship – "Barr body test" / chromosomes
> **1991** IAAF – Recommendation to end systematic sex/gender testing
> **1992** IOC - PCR-*SRY* / chromosomes
> **2004** Stockholm Consensus
> **2011** IAAF and 2012 IOC Consensus Statement on Hyperandrogenism
> **2015** *IOC Consensus Meeting on Sex Reassignment and Hyperandrogenism*
> **2015** Suspension of Hyperandrogenism Rules/2018 Testosterone Level Modification
> **2020** World Rugby Ban on the Participation of Transgender Women

> As well as gender testing, I had psychological testing carried out as a requirement of the process put in place by the international federation. My most private medical documentation was shared amongst men, which were mainly not medical people, but sport people. It was left in their personal judgment if I was female enough to compete. The science behind their policy doesn't exist and therefore these men are being falsely empowered to carry out these acts on women. It is a form of interrogation, rape and humiliation.
>
> **– K. Worley about trans policies evaluation In Brown (2015)**

The USGA has done nothing to develop a policy to include transitioned women on tour. Rather, they have explicitly, through their policy, excluded transitioned women from competing on tour. They request a signed wavier by the entrant giving the USGA complete and unrestricted access to one's medical records and pre-operative and post-operative psychiatric records. And I just find that horrendous. We are treated as a complete freak, and we are treated so differently to any other competitor with complete disregard to the real facts and medical conditions involved in our treatment and the person who we are. It's an obvious policy developed based on emotion and fear.

-- Mianne Bagger about the USGA policy on trans athletes in Love et al. (2009)

A few years ago I was hospitalized. When I told the doctor that I play basketball she told me: "but if you play on a women's team you are a cheater."

-- 40 years-old, woman, non-elite athlete (Interview: 1h50, February, 2019) In Pavlenko (2019, 2021)

Continuing a Long History of Exclusion: The Women's Category of Sport

Policies that impact trans women's participation in elite sport are the continuation of a long history of exclusion of women from competitive sport – an exclusion that resulted in the introduction of a 'women's' category of sport in the first place.

The women's sports category is the result of the historical exclusion of women from competitive sport, which was underpinned by pathologizing discourses about their bodies and the harms of their participation in physical activities. Policies that impact the practice of trans women in competitive sport emanate from the parallel history of efforts to define the female category in ways that excluded those women whose bodies were deemed to not conform to normative standards of femininity.

Forbidden to take part explicitly in sports from the end of the 19th century, women organized their own competitions during the 20th century and gained some access to sports that were prohibited to them (Prudhomme-Poncet, 2003; Rosol, 2004; Vilain et al., 2017). Like the organization of the Women's World Games in 1922 by the FSFI (International Women's Sports Federation) in response to the ban on participation for women in many Olympic events (Castan-Vicente et al., 2019). Throughout this period, women athletes were subjected to a "virilization trial" (Bohuon, 2008): the accusation of not sufficiently meeting the socially expected criteria of femininity, not being enough of a woman by society standards because of traits like - having muscles, wearing sportswear deemed masculine, or because of their hairstyle or body hair (Bohuon, 2008; Vilain et al., 2017).

This virilization trial, which is found in discourses and the exclusion by sports organizations from allowing some women to compete in their competitions gradually became systematized by the femininity test (Bohuon, 2012; Sullivan, 2011). Behind the pretext of protecting the women's category from potential impostors, sports federations sought to establish sex/gender control to police femininity and performances (Bohuon, 2012; Hargie, 2017; Sullivan, 2011; Vilain et al., 2017). In this context, being a woman is understood as having physical capacities inferior to men as evidenced by the sex controls. At the 1966 European Athletics Championship, the athletes were subjected to an anatomical and physical test attesting that they were women. Therefore, if their body matched medical expectations and if their performance were lower than men's, they were cleared as women for the event (Bohuon, 2012; Sullivan, 2011).

Since 1966 we have witnessed different waves of femininity tests implemented by sports organizations (Bohuon, 2012; Hargie, 2017; Sullivan, 2011; Vilain et al., 2017). Anatomical

at first, then genetics, and now hormonal. All tests were inconclusive because contrary to the medical assumption that led to these tests men and women are not dimorphic and show overlap in all those areas (Pape, 2017). Instead of considering non-dimorphic data as part of the diversity of human bodies, these findings when they are related to women's bodies are pathologized, excluded from scientific studies results, and policed in sports regulations (Pape, 2019). Today, in line with medicalization and control of women's bodies by sports institutions, policymakers still (erroneously) assume and insist that: human bodies are dimorphic, testosterone is a male hormone, testosterone is the key to winning competitions, women are inherently weaker than men. These assumptions are implemented without tangible evidence as a way of maintaining patriarchy and the domination of men over women. (Erikainen, 2020; Karkazis and Jordan-Young, 2018; Pieper, 2016; Sanchez et al., 2013; Sullivan, 2011).

Systematic gender testing was canceled in 2000 (Sullivan, 2011). But the controversy around Caster Semenya's victory at the 2011 Athletics World championship re-actualized the debate about medical regulation of women's athletes. "Visual" doubts, therefore, external criteria of racialized cis-heterosexist femininity have been used to enforce gender testing. Resulting in the fact that almost all women targeted by those tests in the 21st century are racialized women from the Global South (Bohuon, 2012; Karkazis and Young, 2018). Making gender testing a way of maintaining power on the geopolitical and racial organization of women athletes' bodies (Bohuon, 2012; Karkazis and Jordan-Young, 2018).

With a regulation like the 2012 IAAF Statement on Hyperandrogenism, racialized athletes from the Global South are sent to the Global North to be "treated", "saved" and taken in charge for their "diseases" (namely having a testosterone level above the expected average by women) created by Western medicine and which do not present any danger for the athletes (Karkazis et Young, 2018). Sex/gender regulation policies are produced by sports organization in the name of fairness without taking into account the living conditions of marginalized women (racialized and/or trans) that actually constitute the opposite of an unfair advantage given the lack of access to resources to train (Erkainen, 2020; Karkazis and Jordan-Young, 2018;).

Social Factors in Keeping Women's Sport Inferior to Men's

There are many social factors involved in keeping the women's category of sport inferior to the men's.

Women are banned from sports competitions. For example, women's marathon was absent from the Olympics Games for 84 years (Vilain et al., 2017). Women were excluded from Olympic boxing until 2012. Women were not allowed to take part in the Olympic ski jumping event until 2014. We can also give the case of the Olympic Skeet event which was originally mixed-gender but, after the victory of a woman - Shan Zhang - in 1992, women were banned from this event at the 1996 Olympics. The possibility for women to

participate in event was reinstated in 2000 with a woman-only category and with different shooting criteria, making it so the performance of men and women were not directly comparable. During the 2021 Olympic canoe-kayak championship, women will not have races longer than 500m, while men's races are 1000m long - another example of differences between men's and women's elite sport which have the effect of maintaining the positioning of men's and women's elite sport.

Other social factors have been forgotten in most articles about competitive differences between men and women: lack of women teams depending on sports and geographical positions; disparities in access to sports facilities for women teams; lack of financial resources (gender pay gap); lack of staff (including medical staff). Sexism in sport impacts women's participation at each step of the game, including on restrictions in muscle/strengthening exercise because of the social representation of what women should look like. Women have had to quit sport, change clubs/trainer, practice in deteriorated conditions due to sexual violence (Ohlert, 2020), lesbophobia (Griffin, 1998), classism, racism, and intersexphobia (Karkazis & Jordan-Young, 2018), or transphobia (Cohen et Semerjian, 2008; Hargie et al., 2017; Ivy, 2020; Jones et al., 2017; Lenskyj, 2018; Tagg, 2012). Faulty and/or absent data about trans women's performance makes transphobia especially present and prominent in this context of scarcity and scrutiny for women in elite sport.

Discrimination and Violence Against Trans Women

Trans women are subjected to discrimination and violence.

The living conditions of trans women are the result of downward social mobility and the many cissexist discriminations they experience in this context. Surveys on the living conditions of trans women in Canada show a strong limitation and discrimination in access to vital spaces (housing, health care, work, public space including sports facilities, etc.) meaning that they can be subjected to violence in every aspect of their life. Trans women are disproportionately affected by unemployment and homelessness (Rotondi et al., 2011). Almost half of trans people who responded to the Trans Pulse Survey earned less than $ 15,000 annually (Rotondi et al., 2011). Trans women are disproportionately remote from salaried employment (Rotondi et al., 2011). Discrimination at work encompasses harassment, physical and mental violence including sexual violence (Grant et al., 2011). More than half of trans women say they feel uncomfortable going to see a doctor (Bauer et al., 2015). Discriminations in this context include refusal to provide care by a medical professional (Bauer et al., 2015). Transphobia impacts access to public spaces - 97% of trans people in the Ontarian studies reported to have avoided at least one type of public space (gyms were the second space most avoided after public washrooms) because of their trans status (Scheim et al., 2014).

These discriminations are incredibly salient to the question of 'fairness' regarding trans women athlete's inclusion in elite sport. There are some ways discrimination impacts trans women's access to sport directly (such as administrators' varying or absent standards of safety and/or availability of necessary sport spaces such as change rooms, training facilities, and washrooms), and others which are a bit more complex but incredibly relevant (for example, the impacts of lower income or availability of secure shelter on participation and/or excellence in sport). All of these factors ought to be taken into account when thinking through the questions of what makes sport 'fair', and are important to understand the context of trans women's participation. This evidence suggests there needs to be more focus on intervening with discrimination against trans women as it appears in elite sport.

Myths About Trans Women Circulated in Sport

There are myths surrounding trans women in sport.

It is a myth perpetuated by and through sport that trans women are akin to cis men. Biomedical studies that inform trans sport policies have cis men as a proxy to trans women in comparison with cis women and use terms like "biological male" or "transitioning males" (Hilton and Lundberg, 2020; Sutherland, 2017). In other words, trans women are assimilated to cis men. The debate is framed not with the concern of trans women's participation in sport, but with the supposed place of a man in the women's category even though trans women's bodies and living conditions are not comparable to cis men's (Ivy and Friedlaender, 2020).

Trans women are assimilated to the stereotype of the cheater who would enter women's competitions with the sole aim of exploiting a single-sex space reserved for women (Hilton and Lundberg, 2020; Sutherland, 2017) – another myth with deep impacts. This fear is unsubstantiated and completely ignores the material living conditions of trans women and the conditions in which women participate in sport. Transitioning, and/or trans women's status as trans, is often utterly misunderstood (at best) in sport discourse as a deliberate choice rather than a necessity for an individual's survival, despite strong evidence that affirming one's gender identity is important to health and well-being. These kinds of presumptions and misunderstandings (again, at best) play into the same unsubstantiated transphobic fears that cis men choose to transition solely to gain advantage in elite sports. However, the discrimination and violence experienced by cis and trans women in sport and everyday life expose the dangerous dismissive attitudes in sport towards trans identities as well as some the contradictions, ignorance, and violences imposed in requiring trans women to adhere to specific medical transition guidelines in order to participate in sports competitions.

It is a myth that trans women 'dominate' (i.e. win) all sports. In response to the literature review on trans athlete's participation in sport by Jones and al. (2017), Richardson and Chen (2020) report a lot of false information without scientific precautions. For example, the fact that several trans women have been the subject of media coverage is used to argue that there are frequent and massive occurrences of trans women athletes winning sports competitions when, in fact, the literature shows that no trans woman has ever won an Olympic medal ever since they have been allowed to compete in 2004 (Ivy and Friedlaender, 2020). Trans women are over-sensationalized in media due to the moral gender panic that surrounds their experience (Espiniera, 2015).

Experiences of Systematic Discrimination in Sport

Qualitative studies with trans women athletes show that trans women face a lot of discrimination while participating in sport.

Negative experience and exclusion of sport participation for trans women are highly reported in the academic literature (Cohen and Semerjian, 2008; Barras, 2021; Devis-Devis et al, 2020; Elling-Machartzki, 2017; Hargie, 2017; Jones et al., 2017; Tagg, 2012). Studies with trans women athletes reveal the anxiety-provoking climate and constant surveillance with which trans athletes must contend at all stages of practice: locker rooms, teammate, opponents, staff, dress codes, supporters, obtaining a license, physical and verbal violence (Jones et al., 2017). This leads to a phenomenon of disengagement from the practice of physical activity and sports in the trans population (Cohen and Semerjian, 2008; Devis-Devis et al, 2020; Elling-Machartzki, 2017; Hargie, 2017; Jones et al., 2017; Tagg, 2012). In addition, discriminatory policies have a role to play in maintaining the climate of violence that trans women experience (Jones et al., 2017). As well as being outed (McClearen, 2015), violence from staff, the public, and being pushed out of sport (Cohen, 2008) and, be faced with having to choose between continuing to play or transitioning (Lucas-Carr et al., 2012). Discrimination shapes sport participation making the trans population proportionally and on average less engaged in sports activities trans cis people (Muchicko et al., 2014). And, we might imagine that these kinds of experiences have negative consequences for their athletic ability and athletic development, though they are not typically factored into scientific studies of testosterone

Knowledge Production and Impact

Different depth, weight, and levels of consideration of scientific knowledge and political factors are imbedded in the framing of trans policies in sport.

The literature on trans sport policies, their implementation, people who write them and apply them, consequences for athletes, and the debates they frame is constitutive of the social hierarchy of knowledge and the discrediting of some sciences for the benefit of others (Pape, 2019). Biomedical studies are overvalued in sports policies in comparison to social sciences studies (Pape, 2019). Research in science and gender and in particular the work of Anne Fausto-Sterling have shown that sex is gender-dependent and that the gender system modifies so-called biological sex (Ritz, 2017). The exclusion of certain types of knowledge from the restricted definition of 'scientific' by the sport's governing bodies makes it possible to obscure the power relations at play in the creation,

maintenance, and legitimization of regulations (Pape, 2017, 2019). Thus, the literature insists on looking at regulations not only at a biological scale, but on the social and political climate that creates them. This analytical framework makes it possible to highlight the links between some sports organizations, studies in biomedical sciences, and groups with an anti-trans agenda.

Scientists working in this field have organizational ties that suggest particular ideological commitments (Itani 2020, Pape, 2019, Pearce et al. 2020). Moreover, some biomedicals scientist that publishes academics paper on trans women participation in sport to advise sports organization are part of anti-trans activism. For example, in the United Kingdom (UK) since 2017 and the plan to reform the 2004 Gender Recognition Act (very expensive, invasive, medicalized, and long process to change the gender marker on the birth certificate), some women's trans-exclusionary organization - such as Fair Play for Women - expanded their movement (Itani, 2020; Pearce et al., 2020). The science is used by this group strategically (using only the data that suit their view) to asset their essentialist agenda that sex is immutable. These organizations use sports as a strategy because preconceived ideas about trans individuals can spread quickly through sport due to the sensualistic medical treatment. Sports are used as a strategy because it emulates strong debate. This allows them to quickly spread their agenda as their target does not look at how the science they used is constructed (Lefebvre, 2019) and rely on misinformation regarding then the implementation of sport policies (Pape, 2000). For example, we can see that there is data that is systematically overlooked, like the diversity advantages that one can have while playing sport. For instance, financial material resources: access to infrastructure, equipment, nutrition, time to train, salary, etc. Yet these resources are not subjected to regulations and are not framed by sports organizations to ensure fairness (Karkazis and Jordan-Young, 2018). It is therefore important to consider the differences in considerations by the governing sports organization between all the sports advantages that may exist and the fact that only biological factors are policed on women's bodies. Because while Michael Phelps (long limbs and flexible joints) is celebrated for his physical advantages that allow him to compete and be successful at the highest level of sport, women (cis, trans, and intersex) are scrutinized and have their performance medically restricted (Jones et al., 2020; Karkazis and Jordan-Young, 2012, 2018).

Approaches to Balancing Biological and Sociological Considerations

As the grey literature revealed, some sports organizations have produced regulations that take into account social issues, discrimination experienced by trans women, and the discourse surrounding their participation in sports competitions. For example, the rules of the UKRDA (UK Roller Derby) a collective sport with important and violent contacts, allow trans women to compete in the women category with no restrictions by taking into account the diversity of women's bodies (cis, intersex, and/or trans) and the many factors of sports performance other than physical capacities, namely technical, tactical and strategic intelligence:

“The UKRDA do not believe that we can prove that transgender skaters experience a physical advantage or disadvantage over cis-gendered (non-trans) skaters. To maintain fairness and equality, and as well as to avoid legal challenge, the UKRDA feel that we cannot categorically state that skaters who identify as a different gender than that which they were assigned at birth experience a physical advantage and we cannot, therefore, utilize the legal exceptions. The legislation states that evidence is required to claim an ‘unfair advantage’. In a roller derby team, there exists a spectrum of heights, weights, natural abilities, and existing or gained fitness levels. Each skater on a team utilizes the strengths they have – whether it be a speedy, explosive jammer compared to a more powerful, offensive style jammer, or a super-agile blocker compared to a powerhouse blocker. It is not therefore relevant to deem a transgender skater ineligible for inclusion in roller derby based on what stage of gender transition they are at or how their physical body presents.”

The statement from the Australian Human Rights Commission Regarding Testosterone and Competitive Advantage notably draws to sports organizations in process of policy-making's attention that knowledge on testosterone is restricted and debated, and many factors outside testosterone influence own’s sports performance and capacities. Further, the statement reminds affected parties that there have been no cases of people transitioning solely to gain advantage in a sport, and that, “for transgender athletes, as for all athletes, sport is about the physical, social and mental health benefits of participation” (p.37). There are, regrettably, also problematic clauses in the statement which permit Australian sports governing bodies to make their own decisions at the elite level and continue with exclusionary practices – more work needs to be done to act, and to seam these acknowledgements closer to implementation.

For a list of some of the sport organizations in Canada who have trans inclusion policies, please see Appendix E.

Conclusion

There is currently no substantial research evidence of any biological advantages that would impede the fairness of trans women competing in elite women’s sport. There currently exists no evidence to suggest that trans women who elect to suppress testosterone (through, for example, gender affirming hormone therapy and/or surgical gonad removal) maintain disproportionate advantages over cis women indefinitely. More specifically, current evidence suggests any biological advantages trans women have in sport performance do not fall outside the range observed among cis women

after testosterone suppression. Red blood cell count is well within cis women's range after four months of testosterone suppression. Strength is a possible exception, a topic on which research is limited/non-existent. Available related research seems to suggest strength decreases over time after suppression, demonstrated through significant decreases in strength (LBM, CSA) after 12 months of suppression and ongoing decreases after the arbitrary one year mark. Even so, the cut-off levels of testosterone for trans women and of the length of time after testosterone suppression in current sport policies are not currently evidence-based. Most biologically-based studies focused on the question of appropriate levels of testosterone for testosterone-suppressed trans women for fair competition among women (cis and trans) and did not arrive at a consensus about (a) whether the question of testosterone is a and/or the most salient biological marker, nor (b) assuming testosterone is an imperfect proxy of heightened and/or 'unfair advantage' in performance, at what levels such advantages are incurred. Further, there is currently no existing evidence on the measurable difference testosterone has on lean muscle mass for active (versus sedentary) individuals, and no research in the context of high-performance athletes that would help understand, for example, testosterone uptake capacities among cis and trans women athletes. There are also questions which remain about what length of time of gender affirming hormone therapies are appropriate to be comparable to cis women on various factors, as well as questions about the definitions of what can be celebrated as a biological gift versus condemned as an 'unfair advantage' and where the boundaries of those are.

Additional biomarkers (such as grip strength, hip angle, bone density) have been used uncritically in positivist biological studies to demonstrate cis men's purported biological advantages over cis women, but there is not sufficient evidence these measures are salient to the question of trans women's participation. In fact, studies often use these measures without examining appropriate comparison populations (often resulting in an uncritical comparison of cis men to trans women, which additional evidence suggests is not apt), possible confounding factors, controls for weight and height, controls for hand size, or other methodological concerns. Some study authors also selectively reported on measures (for example, one review left out the results of a primary study whose conclusion ran counter to their claims), did not include important conflicts of interest (such as funding from groups who support the exclusion of trans women from sport and/or society), and relied on 'common knowledge' claims that were not scientifically supported as foundational assumptions.

There are also key areas of positivist biological research that remain unexplored: for example, the ways in which trans women are biologically disadvantaged in elite sport,

and the ways in which cis women tend to outperform cis men on a population level in some sport-relevant attributes (e.g., endurance, recovery, perfusion, balance).

In this dearth of positivist evidence (evidence which anticipates one objective 'truth'), research indicates that people not only fall back to socio-cultural, historical, geopolitical systems, but are actively engaged in political practices of non-knowledge and active ignorance within these systems when it comes to the topics of gender, sex, and trans women's participation in elite sport. It is within this absence of biological evidence and within these systems that current arbitrary boundaries, policies, limits, levels are formed.

There is strong evidence that elite sport policy is made within transmisogynist, misogynoir, racist, geopolitical cultural norms. There is evidence that the fears that cis women need be protected from trans women in elite sport are unsubstantiated and misplaced: what threatens women's elite sport, for cis and trans women, is not trans women, but is rather misogyny in the form of underfunding, non-parity in participation and leadership, inequitable sport space allocation/access, and a range of sporting opportunities not afforded to women – cis and trans - in equitable ways. Counter to these misplaced fears and in addition to the limited opportunities for women in sport, trans women also face overlapping systems of cissexism and transmisogyny (among others) in accessing sporting opportunities.

To answer the positivist question of what biological factors would make sport 'fair' among cis and trans women, more research needs to be funded and conducted using appropriate, ethical methods and populations. The critical question of what sociocultural factors would make sport 'fair' among cis and trans women can already be adequately answered, but requires transformations and more actions towards equitable sport at the elite level. Many current trans inclusion policies at high-performance levels in Canada act as trans exclusion policies or arbitrary criteria that trans women must meet to compete (Re-creation Collective, 2021), and sports organizers need better education, dedicated resources and high-quality research to confront, disrupt or transform gendered systems.

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Appendix A: Author Recommendations

Elite sports have an opportunity to be at the forefront of evidence-based, broader, transformational change to counter transphobia, transmisogyny, cissexism and other overlapping systems of oppression enacted through sport systems. They have the opportunity to fight against transphobia in sport and more broadly to increase fairness and accessibility to a full variety of embodied diversities. In addition to the trans women who have been excluded from elite sport due to transphobia, transmisogyny, and cissexism, there are also trans women who are currently coming against these systems as athletes within elite sport. While broader systemic change needs to move ahead, harms to trans women in elite sport must be reduced and trans women's safety in and access to elite sport augmented by implementing evidence-based policies now.

There exist significant gaps in the literature, and further research is needed. This research should have trained trans women as a sample population and trained cis women as a comparison group. Additionally, to ensure the generalizability or statistical significance of these studies, an increase to the total number of participants would be required. These studies must also make comparisons with equivalent population groups, such as adjusting for height and weight and not using methods such as handgrip strength which are known to be unreliable outside of population level analysis. On a systems level, we know that trans researchers are more likely to be underfunded and more likely to be marginalized than cis researchers, especially in elite sport research. Much of the biomedical research on trans women in sports comes from cis researchers outside both sports and gender studies fields. Therefore, more dedicated funding and funding opportunities are needed for trans researchers in sport in order to produce high quality data on which to thoughtfully base decisions.

It is the recommendation of these authors that all reasonable efforts should be made to make sport inclusive and accessible for transgender individuals.

The available evidence suggests that at some point within 12 months of testosterone suppression, a trans woman's sex-based advantage in terms of hemoglobin and LBM, CSA or strength are within cis-women ranges. However, for pre-suppression trans women or women within the 12 month period, there may exist a need (within current sport systems) for some policies in elite sports. Any such policy must be carefully designed so as not to discourage potential athletes, to protect the athlete's privacy, including their right to not openly identify as transgender, and to not exclude these individuals during this period from participating with a team through training, social activities, exhibition matches or when competing parties wave objection to the individual's participation.

‘Trans inclusion’ policies and their enforcement, by nature, create additional barriers for trans women’s participation in elite sport. It is the responsibility of the sports organization to create any such policy with the mindset of minimizing any such barrier and prioritizing the needs of trans women athletes. Trans athletes should not have to self-identify, out themselves to their team, coaching staff or sports federation in order to play. Given that elite athletes already require regular physician monitoring for eligibility, policy can be drafted to add a statement that qualifies an athlete if she meets one of several criteria without specifying how or why she is eligible (i.e., if the athlete is either cis and meets the criteria or trans and meets the trans policy guidelines).

The importance of privacy and the need for any policy to ensure trans athletes need not ‘out’ themselves as a condition of playing cannot be over-emphasized. We recommend that any guidelines be enforced for all participants (cis and trans) uniformly, through blind arbitration of a physician with access to the pertinent health records required to confirm that the participant is either cis, has underwent gonadal removal or has underwent adequate testosterone suppression for the requisite period. We also recommend policy be made for trans women who have underwent gonadal removal be exempt from serum testosterone monitoring unless undergoing testosterone supplementation to maintain testosterone levels to within cis-woman ranges as directed by their physician. Doping is a different question – biologically and socioculturally – than trans women’s inclusion in elite sport and must be treated differently in research and practice. An area of promise with regards to this recommendation is providing evidence-based Therapeutic Use Exemption (TUE) clarity and guidance for exemptions for trans athletes, in particular with regards to testosterone. It is, however, especially important to note and apply to any policy that not all physicians are trans positive, and significant barriers exist for trans individuals to seek healthcare – especially with regards to sport (see Pavlenko, 2019, 2021).

Additionally, it is important to note that not all trans women are able or wish to undergo testosterone suppression as part of their transition. As a result, additional consideration should be made into what other metrics may be used instead of testosterone to allow these individuals to compete in current sport system contexts. Possible metrics could include direct LBM measurement through a dexa MRI/scan or other less reliable methods of LBM measurement.

Last, on a systems level, more resources ought be diverted to women’s sport to limit scarcity and increase opportunities for women - cis and trans - elite athletes. In particular, more resources ought be diverted to trans women elite athletes, who face

additional, overlapping, systemic barriers in elite sport from transmisogyny, transphobia, and cissexism.

There are trans women who are currently excluded from elite sport from the same systemic mechanisms that elite athlete trans women face within sport. There must be evidence-based policies to minimize the barriers faced by elite athlete trans women within sport, while also transformations to the sport system towards welcoming all kinds of embodied diversities.

Appendix B: Detailed Tables of Reviewed Academic and Grey Literature

HRT = hormone replacement therapy
HST = hormonal-surgical treatments

Academic Literature

The first eight articles in the table below are primary studies (i.e. individual original research studies) and syntheses (i.e., systematic reviews, meta-analyses, other syntheses) which the authors considered especially important to highlight given their prominence in literature, policy, and/or media. The rest of the articles listed are presented in order of review.

Table 11 Detailed review table, syntheses and primary literature.

Author(s)	Year	Kind of Study and/or Sample	Methods/ Study design (PICO where relevant: Population, Intervention, Comparator, Outcome)	Self-identified trans researcher(s) lead and/or trans research team members?	Key Conclusions	Key Reviewer Criticisms	Other notes
Bethany Alice Jones, Jon Arcelus, Walter Pierre Bouman, Emma Haycraft	2017	Literature review	Systematic literature review Research papers: between 1966 and 2015 with keywords - gender dysphoria, gender identity disorder, trans people, trans individual,	Not to my knowledge	In this paper, the authors conducted a literature review of 8 research articles looking at the social and biological conditions affecting trans people's participation in sport and looking at 31 sport regulations governing trans people's	It is important to note that the regulations are not based on medical evidence but rather on an assumption that stems from cissexism and oppositional sexism	**711-712: conclusion of the analysis of the regulations** "Currently, the majority of sport policies unfairly exclude transgender people from competitive sport, as the requirements they place on them are not underpinned by evidence-

			transgender and transsexual AND physical activity, exercise and sport Regulations: google search		participation in sport. The results show that the majority of trans people have had a negative experience within the sports space. A scientific void is observed surrounding the biological issue of trans people having a supposed physical advantage. Thus, sports governing bodies do not rely on any tangible medical evidence to construct their rules, leading to the exclusion of an already marginalized population from competitive sport in this space. Moreover, this logic leads to the reinforcement of the exclusion process that is already in place.	(Serano, 2007). Namely, the idea that the women's category and the men's category are mutually exclusive and that trans women are in fact men. Under this assumption, federations do not need medical evidence on trans athletes to implement their rules. This is precisely what is denounced in this article. The literature review on qualitative research conducted with trans athletes attests to the violence used against this	based medicine. Until (and if) there is consistent and direct evidence to demonstrate transgender people have an athletic advantage, it seems unreasonable to exclude them on any basis." **713: Difference in consideration of biological vs. social advantage factors** "At the current time, this is a difficult issue to address considering that there is a lack of direct and consistent physiological performance-related data with trans-gender people, which is preventing a consensus from being made as to whether transgender people (especially trans- gender female

						population in the sports space. Trans athletes have to deal with an anxiety-provoking climate at all stages when competing in sports, whether on the field, in the locker room, or through dress codes. Clubs and federations also take part in this institutional violence: the need to obtain a license, discriminatory rules. Finally, this violence can manifest as physical and/or verbal violence from teammates, opponents, staff, supporters.	individuals) do or do not have an athletic advantage. It may be sensible to suggest that until there are direct and consistent scientific data to suggest that trans- gender competitors have an advantage, transgender people should be allowed to compete in accordance with their gender identity with no restrictions (e.g., no requirement to have cross-sex hormones, gender-confirming surgery). The athletic advantage transgender female individuals are perceived to have (based on indirect and ambiguous evidence) may be no greater than widely accepted physiological (e.g., large hands) and

						The 31 regulations named in the article have not been fairly studied. The article focuses on the criticism of IOC rules. The inclusive rules of quidditch or roller derby are not presented (although listed in a table).	financial (e.g., training opportunities) advantages that some cisgender people possess in competitive sport "
Hilton and Lundberg	2020	Analysis of Hilton & Lundberg (2020) Transgender Women in the Female Category of Sport: Perspectives on Testosterone Suppression and Performance	Systematic review	NO	See Appendix D	See Appendix D	See Appendix D

		Advantage					
Harper et al.,	2021	How does hormone transition in transgender women change body composition, muscle strength and haemoglobin? Systematic review with a focus on the implication for sport participation	Systematic review	Yes - lead author	Transwomen experience rapidly reductions to hemoglobin as comparable with cis women. Decreases in strength LBM and muscle area are also observed but are still higher than cis-women even after 36 months. Paper reviews extensively multiple areas that may impact performance such as body fat, hemoglobin, HCT etc.	Authors use reference studies which largely are not height adjusted and are not comparing athletic sample groups. As a result comparisons for LBM, muscle area etc may be overstated due to lack of appropriate comparison groups. Additionally, a statistical significance in higher LBM does not translate into a practical significance or	

						performance advantage which is currently unmeasured. Authors also heavily rely on studies which use handgrip strength to measure overall strength. There are numerous issues with using this as a reliable test. Use of grip strength retained. However, grip strength is largely a correlated with hand size due to gripping testing device easier. (i.e. height) Alahmari,	

						K. A., Kakaraparthi, V. N., Reddy, R. S., Silvian, P. S., Ahmad, I., & Rengaramanujam, K. (2019). Percentage difference of hand dimensions and their correlation with hand grip and pinch strength among schoolchildren in Saudi Arabia. Nigerian journal of clinical practice.	
Hamilton et al.,	2021	Integrating Transwomen and Female Athletes with Differences of Sex Development	Literature review of key leaders in field.	Unknown	There is a lack of data quantifying performance before during and after testosterone suppressing interventions. Other biomarkers are important	Study for testosterone limit is based on a limited sample size study (24 women) who were not elite athletes who	Highly influential paper that should be reviewed by other members of the team. Large section describing consensus statements and

		(DSD) into Elite Competition: The FIMS 2021 Consensus Statement.			including testosterone sensitivity and responsiveness. Longitudinal studies are required to generate data for biological and sports performance for different sports or athletic events. Authors agree on sport-specific policies are needed based on peer-reviewed scientific evidence. Transwomen and women with DSD may still retain some advantage, however this may not be an unfair advantage compared to other genetic or environmental advantages. It may be considered	received testosterone supplement and had moderate performance increases. This highlights a large divide in the literature between elite level athletes, "active individuals" and untrained individuals. Testosterone likely plays a different moderating level for ceiling muscle mass (i.e. maximum results achieved for elite athletes) and the baseline sedentary levels. These two may not	dissenting opinions. There is no thought or reference to potential genetic or developmental advantages that men may have that confer "unfair advantage". While the prevalence of women with DSD and trans women in sports is higher than men with advantage, it seems selective to only be talking about women's protection and not men's as well.

					part of that athletes individual makeup. Recommendation of lowering the testosterone limit to 5nmol/l Argument made against moving "goalpost" of advantage. Author argues that advantage can never be eliminated in sport but is rather a part of peoples unique makeup. -à I would suggest unfair advantage needs to be categorized and agreed too.	be impacted equally. Testosterone is argued as the only available biomarker that is widely available for eligibility purposes. However, I would argue that the "athletic gender" that is presented is widely flawed and can only be seen as "best available metric that is economical in its application". Paper does not include non-biological	

						results including population differences based on access, nutrition/body composition or other determinants of health that can negatively impact these groups.	
Harper, J.	2015	Race Times for Transgender Athletes	- 200 race times from 8 trans women runners (self-monitored and self reported times) - mathematical model (age-grading)	Yes	- 10% slower after transition. - WMA age-grade equivalence before and after.	- Not elite athletes	This study is widely considered foundational to the field, despite methodological concerns and criticisms.
Bermon et al.,	2014	Serum Androgen Levels in Elite Female	849 Elite female track and field athletes were	No	Study established baseline values for serum androgen	Population sample included track and field athletes,	- Why this advantage and not others i.e. Michael Phelps arm

		Athletes	measured for Serum Testosterone levels to determine if this population group has an elevated level of T compared to sedentary cis-women. 99th % of elite athletes (after removing DSD and doping violations) was 3.08 nmol/l below the 10nmol/l limit set currently for hyperandrogenic women with androgen insensitivity.		values for elite track and field cisgender female athletes. Individuals who were confirmed or suspected of being hyperandrogenic (DSD) or doping individuals were excluded. Study admits however that not all individuals who are DSD or doping would necessarily be filtered out. Individuals were asked about their Menstrual status and oral contraceptive use. Additionally, confounding variables such as athletic event, age and ethnicity were also all evaluated. Authors suggest that	as a result this result are note generalizable to other sports or events where high T is an advantage. (evidence for cardio based activities minimizes T advantage compared with strength-based events). All but FT differed significantly between types of events (age for sprinters was sig, while long distance runners had below average serum T levels) - DSD is noted as	span, oxidization etc. Interesting crossover between doping concerns and baseline testosterone levels for women's sports. - Historical bias (i.e. 1972 Olympics & soviet fears of forced doping.) - Must evaluate not just effect of T but also DHEAS, SHBG or other receptor base which makes testosterone levels actually impact muscle mass i.e. strength/athletic impact.

					baseline hormonal profile information can be used to develop an Athlete Biological Passport (ADP) for evidence based fair policies and recommendations around anti-doping regulation. However, it is important to note that, - "There is no clear scientific evidence proving that a high level of (sic, naturally produced) T is a significant determinant of	140x more prevalent than in normal population, this evidence should be examined for selection bias or under-representation of population sampling (i.e. we test athletes but not all individuals). - ADP has been shown to be a more effective deterrent on doping in sports (5) and may be encouraged from a player safety and fairness perspective. - Large distributio	

					performance in female sports” Authors do not and mention that DSD is overrepresented in elite athlete population group as an indicator that DSD and high levels of testosterone are indicative of high performance (i.e. selection bias of competition) à (should check for social factors as well i.e. physical appearance may socially select individuals to participate in sport).	n P0-P100 and P25-P75 suggests 99th% may not be as significant towards athletic effect. Serum T levels were not compared to athletic success at these events. As such is may be disingenuous to say that any population-based cut-off is appropriate. Elite athletes represent the top 99th percentile in athletic results (including speed, strength etc) and therefor mean population distribution has little	

						meaning as all elite athlete individuals are edge case scenarios. - Measurement time for T is highly varied by time of day, this makes baseline testing very difficult unless T is measured repeatedly over several time intervals.	
Roberts, T. A., Smalley, J., & Ahrendt, D.	2021	Effect of HRT on certain physical abilities of trans men and women	**PICO where relevant: Population, Intervention, Comparator, Outcome) Population:** 29 trans men and 46 trans women in the U.S. military, between the	No	***Background:*** The authors postulate that testosterone gives athletes a physical advantage when competing. The major changes occur during the first year of HRT.	This research suggests that it is possible to evaluate the physical abilities of trans athletes before and	Terminology: Transmen/transwomen or transgender "cis gender women"

			ages of 19 and 46 (78% were under 30). **Intervention:** Comparison of performance before and during the first 30 months of HRT. - Number of push-ups in 1 min - Number of sit-ups in 1 min - Time taken to run 1.5 miles (2,400 m). **Comparator**: cis men and cis women, no information given on the number, the average height/weight of the cis men is provided = 178/83 as is the average height/weight of the cis women = 164/65. **Outcome:** Trans women: increased		***Methods:*** *Study population* - 29 trans men and 46 trans women under the age of 30 who are in the US Army, between 2004 and 2014. *Outcome measures* - fitness testing before HRT, during and after the first year on HRT, and for 30 months after starting treatment. ***Results:*** *Effect of gender affirming hormones on body composition and athletics performance* - The age at which the athlete begins HRT is shown to have no impact on the results. For trans women, estrogen intake is associated with weight gain and decreased physical ability. For trans men, testosterone is shown to have little impact on weight, but it increased their physical abilities. *Athletic performance*	after starting hormonal treatment. However, the number of variables analyzed is limited. Drawing conclusions about athletic performance based on the number of push-ups and sit-ups a person can complete and how fast they can run 2,400 meters seems like a flawed exercise. Indeed, succeeding in these exercises cannot be correlated with an expectation of a high or very high level of performance in many sports. For example, the number of kick-ups that a person can	

			weight, decreased performance. Push-ups and sit-ups per minute comparable to cis women after HRT. Running time - performance lower than cis men but better than cis women after HRT. Trans men: no significant change in weight, increased physical capacity. Number of push-ups per minute comparable to cis men after HRT. Number of sit-ups was comparable to cis men before HRT, increase in this performance after HRT. Running time similar to cis men after 1 year of HRT.		*among transgender service members* - Before HRT, trans women had a lower push-up score per minute than cis men, but higher than cis women. This difference was no longer present after two years of hormone treatment. The same is true when it comes to the number of push-ups completed. Their running times after HRT were lower than for cis men but not as low as for cis women. The trans men in the study did more push-ups than cis women before HRT but less than cis men. After one year of HRT, the difference between the trans men and cis men had disappeared. ***Discussion:*** They suggest waiting more than a year before allowing trans women to	do in soccer cannot be correlated with their level of performance in a game. Another interesting finding that has not been widely discussed is that trans men, who were trans before they started taking testosterone, performed better than cis women in push-ups and sit-ups. More importantly, they performed a similar number of sit-ups to cis men. The level of testosterone in the blood can therefore hardly be the only indicator of performance in sports.	

					compete in the female category. *Study findings and prior research*: Trans men's physical abilities increase while trans women's physical abilities decrease. A difference is seen between strength and endurance events. Dysphoria and its impact on athletic performance must be taken into account. This would explain the higher physical abilities of trans men compared to cis women in push-ups and the opposite for trans women.	Intra-group differences are not analyzed.	
Wiik, A., Lundberg, T. R., Rullman, E., Andersson, D. P., Holmberg, M., Mandić, M., ... & Gustafsson, T.	2020	n= 23 of which n= 11 trans men n= 12 trans women	**(PICO where relevant: Population, Intervention, Comparator, Outcome)** **Population:** trans men (n=11) with an average age of 25 years and trans women (n=12) with	No	Biomedical study of trans men (n=11) and non-athletic trans women (n=12) during their first year of hormone treatment. Knee extension and flexibility, muscle size, and radiodensity measurements were taken.	Population: We do not know how many cis men and cis women participated in the study. We don't know what is going on with cis people: is	Terminology: Transgender men, transgender women, gender identity

			an average age of 27 years, all non-athletes **Intervention:** biomechanical measurements (radiodensity, muscle size) **Comparator:** cis men and cis women. Number not reported. **Outcome:** Increased muscularity in trans men, slight decrease of muscularity in trans women after 12 months of HRT		The results show that the trans men showed a 15% increase in muscle mass in their thighs and quadriceps and a 6% increase in radiodensity. The trans women lost 5% of their muscle volume. No change was observed in radiodensity. The trans men experienced an increase in muscle strength while the trans women did not experience any chance in this area.	there an increase or a decrease? No intra-group comparisons This paper has several notable weaknesses which must be considered. These weaknesses do not justify the broad implications that are asserted within the paper or by its proponents. These weaknesses are : - Very small sample size (N = 11 TW, N = 12 TM). Further:No indication of how participants were recruited or selected; Were all patients	

						offered opportunity to be in study, and was everyone offered to be in the study included; Unknown bias by recruiters, i.e. use of a script?; Study conducted at a single center, represents a specific su b-populat ion in Sweden; Non-athletes were used as a proxy; - Issues relating to measuring and reporting of data collected such as: Baseline measureme nts done after 4 weeks gonadal suppressio n; States some strength, size parameters	

						greater in TW than TW or CW. However, does not show range of data and overlap, does not state if TW were outside normal range for TM or CM. CW measurements were obtained separately and prior to TW and TM; Few strength-based attributes measured, other measurements may be relevant; Other non-strength-based measurements may be relevant (eg: muscular endurance, repetition, V02 max); Persans recording strength measurements were not blinded;	

						No measurements beyond 12 months gonadal suppression, only 11 months after cross-hormones added and with 11-month testing in multi month interval. Unknown where changes peak, cannot predict ongoing effects muscle strength, size; No discussion if inter-group differences vs intra-group differences; - Strength, size, radiography density used as proxies for athletic performance. This is problematic : Significant	

						differences in muscle strength, size, density may not correlate to a significant difference in athletic performance; Even if athletic performance were maintained in TW, this would not necessarily correlate to a safety issue	
Katrina Karkazis and Rebecca M. Jordan-Young	2018	Theoretical article, Discourse analysis	Analysis of the speech given at the IAAF by Stéphane Bremon, one of the members of the IAAF medical commission, during a presentation made in 2012 on the regulations that apply to hyperandrogenic athletes	No To my knowledge, the two researchers do not identify as being intersex (therefore they are assumed to be dyadic)	In this article, the authors show that the IAAF's regulations on hyperandrogenism and the arguments that surround and construct them are based on sexist, racist, and colonial assumptions. - "T talk", i.e., the dialogue surrounding the use of testosterone. This dialogue perpetuates the myth and misrepresentation of this hormone as	The article is interesting in that it shows the racial and geographical constructs of athletes who are accused of not fitting into the expected body standards of femininity. However, the article does not directly address	**29: Hormone-based regulations put all athletes at risk** "T talk" deflects attention from social structures and institutions, attributing the result of competitions completely to individual bodies, as though these bodies have developed, trained, and ultimately competed in some socially-

					being a "masculine hormone" by attributing all social behaviors of masculinity to it. Attributing gendered social behaviors to hormones in this way is central to the hierarchical positioning and normalizing of a rigid dichotomy of the sexes. This dialogue is so socially anchored that it can exist without a concrete scientific/biological basis. Indeed, the authors explain that if there is a group-level correlation between testosterone and strength, speed, and muscle mass, such a correlation has not been proven at the individual level. In other words, these abilities cannot be directly correlated to testosterone levels alone. The strength and pervasiveness	trans athletes, since it is about cis intersex women. We can take away the following key points (or at least draw some parallels) from the article: that the regulations that trans women are subjected to form part of the history of the frameworks used to exercise control over women's bodies which are imposed by the medical profession. Such frameworks are based on gender and racial stereotypes that have important ramifications when it comes to athletes'	neutral vacuum. At one level, the regulation harms all women athletes."

					of this dialogue allows the differences in access to sport between the Global North and the Global South to be hidden. - So-called "regimes of care", provide an explanation for the IAAF's justification of the implementation of these rules. These "regimes of care" perpetuate gender and race inequalities because under the pretext of care, athletes from the Global South are sent to the Global North, in this case, to France (a country that has a repressive migration policy) for the purpose of "treating"/ "saving" said athletes, whose countries' medical frameworks would not be able to effectively treat hormonal "pathologies", as they are defined in western	health and wellbeing. And above all, that no considerati on is given to the real lived experience s of the athletes who are subjected to the regulations, and who come from marginalize d and oppressed populations in terms of gender and race. Furthermor e, the dialogue surroundin g testosteron e is not based on any tangible medical evidence. This is demonstrat ed by the examples that are mobilized by the member of the IAAF medical commissio n, which	

					medicine, even though such hormonal "pathologies" present no danger whatsoever to the individuals who are affected by them. - The IAAF links doping to naturally high testosterone levels	were analyzed by Karkazis and Jordan Young. The painting of *La maja desnuda,* by Goya, (1797-1800) is used to represent the ideal woman: a white woman, non-athletic, naked, and lying down. The ideal man is represented by a black bodybuilder who is known to have doped for more than 20 years.	
Andrew Richardson and Mark A. Chen	2020	Response to the literature review by Jones et al. (2017)	None	No	This article is a short response to the literature review by Jones et al. (2017). The authors wish to challenge two points: the fact that trans women would not have a physical advantage over cisgender women and, the failure to	This article relays a lot of false information without scientific precautions. For example, it is highly problematic that a number of trans women have been	

					consider the usage of "inclusion policies" (their term) when it comes to sports requiring specific physical qualities such as size and strength. ***Transgender female advantage***: To support their hypothesis that trans women have a physical advantage over cis women, the authors take the case of Laurel Hubbard (weightlifting), comparing her "pre-transition" (their term) and "post-transition" (their term) performance, noting that the difference is only 7%. They also highlight the fact that she would benefit from her years of training in the men's category. This point is accompanied by a paragraph citing various trans women who have appeared in the media.	subjected to media enquiries (cissexist, sensationalist, and resulting in media abuse (Espiniera, 2015)) and that these enquiries have been used to prove that trans women have a physical advantage and pose a problem in certain sports. The authors contradict themselves by saying that running is not a strength sport to counter Harper's (2015) study, while they cite Terry Miller and Andraya Yerwood (track and field, sprinting) as evidence of physical	

					Transgender sporting policies: The authors claim that Jones et al. (2017) did not consider strength sports such as weightlifting, bodybuilding, MMA, wrestling, judo, rugby, or rock climbing (among others cited). The next paragraph cites the USAPL rulebook that would have provided evidence of the physical advantage of trans women. They end by citing Harper's (2015) study, saying that it proves nothing since it is not about sports (5k to 42k) that require physical abilities such as strength or speed.	advantages in sports that rely on strength, speed, and size. To cover their backs, they explain that for a marathon or a 5k race, you only need endurance (and no other physical ability). It is quite contradictory to isolate physical abilities in this way, especially in sports, which generally require a combination of many different physical and mental abilities. The surveys cited to attempt to prove that trans women have a physical advantage are not based on	

						the performance of trans athletes but on the performance of cis men and women. They compare trans women to cis women on the basis of cis men and cis women.	
Bethany Alice Jones, Jon Arcelus, Walter Pierre Bouman, Emma Haycraft	2020	Response to a critique of their literature review, which was published in 2017		Not to my knowledge	Jones et al. address the points put forward in the critique of their first article to show how biased the interpretation of it has been. They offer up some possible avenues to address the cissexist argument (this term is not used in the text) that has been put forward. ***Transgender female advantage*** – They highlight that at no point in their article do they state that trans women do not have a	This article highlights that the points of criticism in response to their article (on the systemic barriers experienced by trans athletes) are not based on consistent scientific evidence. Looking to news articles or scientific studies of cis people to make the argument about the supposed physical	

					physical advantage, but rather that there are currently no scientific studies that prove a physical advantage. Jones et al (2020) point out that Chen and Richardson use sensationalist media articles to support their argument without reference to scientific literature as supporting material. The third point of response revolves around the fact that some physiological changes that produce physical benefits are accepted, while others (unproven), are not, such as Michael Phelps' physiological characteristics and the advantages that these characteristics bring. *Transgender sport policy* - Jones et al. raise the fact that	advantage of trans women cannot be considered as valid forms of evidence. The example of Michael Phelps is an interesting one. This example is often used in feminist literature (in the field of the social sciences of sport) to demonstrate the differences in consideration with regard to what is used to demonstrate an ethical physical advantage and what isn't. In particular, this example is often used to counter the dialogue about what	

					"*outdated*" (p.1862) studies on the differences between cis men and cis women are used in Richardson and Chen's (2020) response to prove that trans women have a physical advantage. Jones et al. also point out that there are already competitions whose categories are not based on sex/gender but rather on athletic ability, such as the *Limitless Strength Competition* in the UK. In response to Richardson and Chen's (2020) proposal to create sport categories specifically for trans people to compete in, Jones et al. conclude by explaining that there is no scientific evidence of this approach being useful and importantly, that trans people do not want to	level of testosterone is supposedly too high for sportswomen like Caster Semenya, Dutee Chand, Anet Negessa, etc.	

					compete in a separate category.		
Arne Ljungqvist	2018	Document which chronologically surveys the implementation of the different IOC regulations		No. Details: IOC member from 1994 to 2012, + IAAF and World Anti-Doping Agency (WADA) member	In this article, the author looks back chronologically at the evolution of IOC regulations regarding intersex and trans athletes. He situates the regulations for trans athletes in the history of the femininity testing in sports competitions. He posits that the key to athletic performance is the difference in testosterone levels between women and men. He refers to testosterone as the male hormone. He argues that the existence of these systematic regulations since the 1960s is due to the need to protect the female category from intruders (= men who would come to compete in this category in	This article puts forward different points: testosterone is the key to performance in sports, it is necessary to protect the female category from intruders (men), that hyperandrogenic athletes have a physical advantage, that there is supporting evidence. However, there are no articles supporting these arguments in the bibliography. This article demonstrates the transmisogynous preconcepti	

					order to win medals). He explains that the 2003 IOC rule emerged following a request from a national Olympic federation regarding the "case" of a trans athlete. He mentions that opponents complained to this federation. Following Caster Semenya's victory in 2009, the IOC brought together biomedical researchers to establish a regulation on her presence. These discussions lead the IOC to stipulate that the gender bicategorization of competitions must absolutely be respected to "protect" all sportswomen. In 2011, the IOC publishes the regulation on hyperandrogenic athletes. The author refers to the ruling initiated by Dutee Chand at the CAS in which the IAAF was given 2 years to	ons (Serano, 2007) that sports federations rely on. The idea that a trans woman would actually be a man (paragraph 1), the idea that trans women could use their femininity to infiltrate (cis) women's spaces. As well as on sexist presuppositions that (cis) women would need to be protected and therefore that the “women’s” category must remain inferior to the “men’s” category (last paragraph). Thus, the regulations are established	

					prove that athletes with a higher-than-average testosterone level than other women have a physical advantage. The author does not seem to doubt (article published online in Oct 2017) that the IAAF will have evidence to put forward. The last paragraph seems alarmist in that the author calls on the sports world to establish and impose regulations to protect the female category, even in countries that allow people to transition medically and legally.	not only on the basis of biological data (which are, moreover, not exempt from biases and power relationships) but are also based on discriminatory preconceptions.	
Sánchez, F. J., Martínez-Patiño, M. J., & Vilain, E	2013	Theoretical article	Critical analysis of the IAAF and IOC regulations in 2011	No	In this article, the authors present a critique of the 2011 IAAF and IOC regulations and the responses that have come through social science research. In the first paragraphs, the authors review	The main point of this article is that the authors highlight the negative repercussions of such regulations on the living conditions of the	**112: The violence with which medical tests/interventions are conducted and the whirlwind of media coverage on sportswomen = these have a negative impact on their living conditions**

					the story of Maria José Martinez-Patino, who was excluded from athletic competitions after a chromosomal test. In this context, the athlete was examined under the microscope by doctors and was the object of an important media enquiry that questioned her belonging to the female category. This situation had negative repercussions on her sporting career and on her life. ***The new policy is not about proving sex***. The new policy is not about who is a man and who is a woman, but about medically defining the boundaries of the female category. The regulations were based on the idea of sexual dimorphism. However, the data show that the female and male categories	sportswomen who are targeted by them. On page 133, the case of Ratjen at the 1936 Olympics is presented but without putting it in perspective with the socio-historical context or analytical precautions as Bohuon (2012) does. On page 144, the authors put forward a link made between homosexuality and congenital adrenal hyperplasia in women. In an article, Michal Raz (2016) offers a proposed response to this result: "As for the results published	"Even though she identified as female throughout her life, her sense of self was called into question because of the results of a cytogenetic test. After being subjected to intense medical and media scrutiny, it was determined her condition rendered her incapable of benefiting from the presence of the Y chromosome and she was once again reinstated in athletics. Nevertheless, her life and her athletic career were forever scarred by the incident (see Martinez-Patino, 2005). “

					are not biologically mutually exclusive. Chromosomal testing is not effective, since women can have an XY karyotype. The authors use the case of Ratjen to show that men do not necessarily perform better than women. ***The new policy does not aim to disqualify athletes with intersex conditions***: DSD do not necessarily give rise to a physical advantage. E.g., those experiencing androgen insensitivity. Such women will not be excluded from competitions even if they have a higher-than-average testosterone level. ***The problem with grouping***: The authors are opposed to the creation of a third sport class. Doing so would be even more detrimental to	on the sexual orientation of these individuals, no conclusion seems to be definitive, with rates of heterosexuality or homosexuality varying widely across the board, likely reflecting differences in the methodologies of these studies. In any case, some publications continue to refer to homosexuality as a "sexual orientation disorder" (Bouvattier 2007), perpetuating a pathologizing viewpoint." Raz, M. (2016). Quality of life and fertility in	

					the athletes involved. Stereotypes influence athletes' performance. It is expected that female athletes will perform less well, so everything is done to ensure that this is the case. To break this rule is to risk being excluded from competitions. ***Conclusion***: Athletes affected by the rules must be given a voice in this debate.	follow-up studies of intersex individuals. *Cahiers du Genre*, 1(1), 145-168. Finally, the conclusion that can be drawn from this type of article is that studies could be carried out on other body differences (e.g.: short vs. tall). However, in a patriarchal and racist society, certain data are put forward for comparison between groups that are considered homogeneous and natural by the dominant group while in fact, this stems from a social relationship of domination.	

Pitsiladis, Y., Harper, J., Betancurt, J. O., Martinez-Patino, M. J., Parisi, A., Wang, G., & Pigozzi, F.	2016	Theoretical article / discussion		Yes - a trans woman and an intersex woman.	The authors explain that there is a lack of scientific knowledge about the supposed advantage of trans women in sports competitions. Among the studies mentioned, the authors start with Gooren and Bunck (2004) who demonstrate that during the first year of HRT, trans women have testosterone levels that fall in the middle of the levels seen in cis women. Then, referring to T'Sjoen et al. (2009), trans women observe a loss of muscle mass and bone density as early as 6 months into their HRT. These studies therefore support the IOC regulations that allow trans women to compete in the women's category provided they	This article points out the limitations and data that still need to be collected in order to gather more information about trans athletes.	Terminology: transgender women, MTF, male and female biology, female athletes, FTM, MTF transition

					are on hormone therapy. However, the authors also point out the lack of data on high-level trans sportspeople. The only biology study conducted to date with trans athletes was conducted with trans women at the amateur level (Harper, 2015). The authors therefore call for more research on the physical and physiological conditions of trans athletes compared to cis women.		
Sutherland, M. A., Wassersug, R. J., & Rosenberg, K. R.	2017	Does not use their own data	Discussion of published studies to draw their own conclusions about trans women	No	*Intro:* IOC regulations in 2004 and in 2016. *Olympic history:* Traces the history of the femininity test in sports competitions by fixing Ratjen's participation in the 1936 Olympic Games as a starting point and then highlighting the chromosomal test (Barr body and PCR-SRY),	Page 174: the authors postulate that the sporting federations' fear of seeing a man compete in the female category dates back to the Olympic Games of 1936, which saw Ratjen compete:	Terminology: Transsexual, biological males, genotypically male, MtF transsexuals, osteological males, human female, Correlation "transsexual" and "transhumanist Deadname Renée Richards.

					in use since 1968. Then, the problem of chromosomal testing for CAIS athletes is discussed. ***Transsexuals in sports:*** Starting with the 2004 regulations. The authors postulate that trans women have a biological advantage over cis women even after HST due to their skeletal/bone structure. ***The osteological advantage:*** The authors state that the human skeleton cannot be modified by transitioning, which means that trans women have a physical advantage. The physical advantage that men have would be due to testosterone giving them a more imposing skeleton. ***Specific osteology and biomechanical advantage: the case of the knee*** The authors	False, if you refer to A. Bohuon and C. Louveau on the "process of virilization", which sportswomen were required to undergo even before 36. In particular, the case of Violette Morris can be quoted. Violette was excluded from the FSFSF (Fédération des sociétés féminines sportives de France) with a lawsuit in 1930 for wearing "masculine clothes". Page 175: The authors point to a study that shows that women with CAIS have an average	

					postulate that one of the key differences between (cis) men and (cis) women is the *Q-angle* ("the angle at which the quadriceps muscle meets the patella compared to the line formed by the ligament connecting the patella to the tibia" physicaltech.com). This difference in angle would have influence in sports such as football/soccer or cycling. ***The case of the elbow:*** In this part, the authors are interested in the *carrying angle* (the physiological valgus of the elbow = the same type of calculation but for the elbow). The authors postulate that this angle is a dimorphic feature even though they admit that this hypothesis has not been empirically	height of 1.70m, while women without CAIS have an average height of 1.65m (stating that the women with CAIS would not have a physical advantage). However, in Danilovic's (2007) study, for example, women with CAIS range in height from 1.54m to 1.80m, so creating an average over such a small number of women seems like a flawed approach, especially without looking at the standard deviation. The study cited by Sutherland et al. (2017)	

					verified and even though no studies have been carried out on the correlation between the accuracy of a shot and this angle. ***The pelvis:*** The authors postulate that this feature is also dimorphic even though they admit that studies have failed to show a correlation between better motor performance and pelvic size. It is suggested that the advantage for men would be that their average pelvic shape would be correlated with fewer injuries. ***Fairness in the field:*** The authors propose to implement osteological and biomechanical tests to classify athletes according to this data in order to ensure fairness in sport. ***Transsexuals as pioneer***	does not specify the number of women with CAIS who were counted. (Danilovic, D. L. S., Correa, P. H. S., Costa, E. M. F., Melo, K. F. S., Mendonca, B. B., & Arnhold, I. J. P. (2007). Height and bone mineral density in androgen insensitivity syndrome with mutations in the androgen receptor gene. Osteoporosis International, 18(3), 369-374). In the article, the authors put forward the variable of height as one of the physical advantages that trans	

					transhumanists: The authors compare gender transition to transhumanism and call for vigilance regarding the various physical modifications that could be made by athletes to improve their performance.	women possess, especially in volleyball. However, in a total contradicti on, on page 177, it is stated that if you take the average height of all the volleyball teams in the Olympic Games, (with one exception since 1968) it has never been the tallest team that has won. Page 179: The authors argue that the high frequency of knee injuries in women is linked to the Q-angle. However, they do not take into account the differences between men and women	

						with regard to the way in which they compete in sports (the condition of the playing surface, the quality and number of training sessions completed, shortages of medical staff and follow-ups, lack of access to weight rooms, etc.). The problem is that gender is the variable that is being studied when looking at health. Living conditions are not taken into account. Page 186: The authors propose that athletes	

						should compete in categories according to their bone/skeletal structure, but they don't take into account the fact that athletes adapt their physical abilities according to their morphology. Furthermore, this suggestion stands in contradiction to their postulate that bones/skeletons are dimorphic in nature. If this were the case, why suggest separating competitors into categories in accordance with their bone structure? This proves that the aim of the	

						study is just to hide the authors' real agenda, which is a desire to force trans women to compete in the male category (without explicitly saying that this is the motive and without tangible medical evidence, since the studies cited were not carried out with trans athletes). In addition, this study (Grelsamer, R. P., Dubey, A., & Weinstein, C. H. (2005). Men and women have similar Q angles: a clinical and trigonometric evaluation. *The Journal of bone and*	

						joint surgery. British volume, *87*(11), 1498-1501.) is not cited in the paper. However, it shows that when comparing men and women of the same height, a similar Q-angle is obtained. Thus, the difference is to do with the person's height rather than their sex. It is also worth noting that the example of the Olympic shooting event, which was originally mixed, was separated into non-comparable categories by sex (not the same distances) following	

						the victory of women in this event. This calls into question the physical advantage argument Another overlooked fact is that bone data are the result of both biological and sociological factors as Anne Fausto-Sterling shows: "Fausto-Sterling's (2005) account of bone density provides a clear ex-ample of how this plays out in scientific discourse and practice. Although sex is widely understood to be an important factor in	

						bone fragility, few studies go beyond a male/female comparison to "examine the relationships among childbirth, lactation, and bone development" (2005, 1492), among other sex/gender-related factors that may influence bone strength, thereby re-informing the dominant tendency to treat sex as a singular, simple, binary variable. Fausto-Sterling offers a systems approach to thinking through these issues, which is able to	

						"[embed] the proposed subsystems within the dimensions of gender, socioeconomic position, and culture" (1515). " (In Ritz, 2017: 321).	
Tannenbaum, C., & Bekker, S	2019	Commentary on the 2018 IAAF Regulations		No	This article offers a commentary on the 2018 IAAF regulations and the medical supervision of the women's category. ***New eligibility criteria***: The maximum testosterone level is arbitrarily set at 5nmol/L. The author reminds the reader that hormonal levels are not mutually exclusive between women and men. There are no studies that prove a causal link between testosterone levels and sports performance (medaling) because there is	The article does not mention trans athletes. It is more a general commentary explaining the IAAF 2018 regulations. The authors point out the limitations of such regulations: errors made in the initial investigation, no proven evidence, consequences for the athletes. Page 1-2: It is stated that the	Terminology: This article does not refer to trans people.

					no data available on this. This would require the systematic testing of all athletes. The survey conducted by the IAAF on the influence of testosterone on athletic performance shows a greater effect in the hammer throw and pole vault (4.53% and 2.94% respectively), even though these disciplines are not governed by IAAF regulations. Moreover, this study is marred by the "data errors" that the researchers have admitted. ***Far reaching implications:*** These studies are conducted for the purposes of the federations that commission them. They have an important impact on the lived experiences and athletic careers of the athletes.	highest percentage correlation between testosterone levels and performance is seen in the hammer throw and pole vault events. However, the authors do not explicitly state that these disciplines are not covered by the IAAF regulations.	

Klein, A., Krane, V., & Paule-Koba, A. L.	2018	Qualitative analysis. N= 1 (trans man)	Methodology: The researchers followed the first year of a trans man's hormonal transition. The trans man in the study was playing sports at university at the D1 collegiate level (running). The data in the wider project were collected through interviews and video diaries. This article focuses on the results extracted from the video diary. Participant: 20 years old, trans man, pronouns he/him, track and field - cross country, D1 student athlete (USA collegiate). From the beginning of his hormonal treatment, he	No	This article focuses on the first year of a trans athlete's transition. The athlete was studying and competing at a university in the US. The article alternates between long transcribed excerpts from the athlete's video diary followed by comments written by the author. The main takeaways are the effects of his hormonal treatment and the constraints he faces with regard to wishing to compete in a different category. The participant reports the body changes that he noticed during his first year of hormonal treatment (he was taking testosterone): genital growth, cessation of bleeding, facial hair growth, hair growth changes, a small increase in muscle mass,	The authors fail to take into account both the social effects of taking testosterone and the psychological effect of taking hormones, nor do they consider how these two factors may also be interdependent. Thus, when the participant mentions being able to *pass* and that he is beginning to feel better mentally, we should consider this not only in terms of biology but also in terms of social factors. This article shows that even in a space where	**555: Definition of transgender** "Transgender can be an umbrella term for any individual whose gender identity and/or gender expression is incongruent with their physical sex (Krane and Symons 2014). Some transgender, or trans, people will identify and desire to be recognized as a different sex than they were assigned at birth. Others may identify as genderqueer, non-binary or gender fluid in which their gender expression is a combination of or shifting among traditionally masculine and feminine traits." **556: Definition of transition** "Transitioning is the process during which a transgender

			is no longer allowed to compete as part of the women's team (as per NCAA rules), but he was not immediately integrated to the men's team either.		and lower fat distribution. In addition, the participant announces that he will stop playing collegiate level sports at university because of the obstacles he encountered during his transition. The authors propose the implementation of a *redshirt* year that would allow athletes to keep their scholarship and transition without losing a year of eligibility.	coaches and other athletes are not directly rejecting his transition, Bryan faces many obstacles which eventually lead him to stop competing in sports at university. Bryan outlines and explains the difficulties he faces when trying to continue competing in sports during his transition. For example, not being able to access a mastectomy is a hindrance which limits his motivation and involvement in sports. As a result, he makes the	person alters their1 gender expression to be consistent with their gender identity. This may include changing the type of clothes they wear, restyling their hair, and/or changing their name and preferred pronouns. Some transgender people may choose to alter their bodies through hormone therapy during their transition and some may have surgical interventions. There is not a single way to transition; instead, 'there are multiple possibilities to transition and various ways to be and become one's gender' (Farber 2017, 257). Transitioning athletes will develop the path most suited for them and that which best

						decision to stop competing. He explains that giving up his sport (running) will allow him to do more weight training and focus on his transition. He talks about the sacrifice he has to make, saying that he feels the need to choose between his two identities: being trans and being an athlete.	portrays and leads to comfortable sex and gender presentation.”
Pape, M.	2017	Discourse analysis	Document 161, a report on the CAS ruling of the Dutee Chand vs IAAF case	No	In this article, Madeleine Pape demonstrates that sports institutions operate in line with the following principle: biological sex precedes social gender. She describes sports governing bodies as *gender-*	Two key takeaways can be drawn from this article: the fact that (at all costs) the sports institutions try to maintain the essentialist postulate that sex	Terminology: transgender **180: Difference in consideration between the sciences (social and biological)** "I find that Chand's victory does not actually amount to a

					determining institutions. That is, spaces where the notions of sex/gender are contested, debated, and defined in ways that reinforce the gender system, the differential valence of the sexes (not in these terms), and heteronormativity. Thus, the author analyzes how the categories of sex/gender/sexuality were destabilized by the athlete and then reified by the institutions during the trial (Dutee Chand vs the IAAF) - The IAAF's regulations form part of a history of exercising control over women's bodies and over women's performance. Indeed, in the gender system, women must be inferior to men in order for men to maintain their	precedes gender and that their ability to maintain their domination on the basis of the rules is dependent on the organization of hierarchical scientific knowledge. - Theorists in the social sciences, in particular within the fields of gender studies and within feminist criticism of the sciences, have demonstrated that it is in fact gender which precedes sex. In other words, the values attributed to men or to women do not come	liberal shift in the sex/gender/sexuality system and the institutions that maintain it. The "non-scientific" claims of Chand's witnesses were ultimately marginalized within the courtroom space in favor of certain scientific criteria for gender determination, allowing hegemonic notions of the nature of sex and gender, and the relationship between them, to prevail."

					dominant position in the hierarchy. For this reason, not only have rules been and continue to be put in place, but various tools for maintaining the hierarchy exist, such as the sexualization of women's bodies and the promotion of heterosexuality, or the lack of remuneration and financial means granted to women. - There is a hierarchy when it comes to the consideration and valuation of scientific knowledge. Studies conducted by life scientists are deemed more valid than studies conducted in the social sciences. The results of such life science studies are given more weight. The gender system is thus perpetuated, since men dominate in the life sciences	about organically but rather they are a product of a social hierarchy whereby men dominate women (i.e., concepts including: the differential valence of the sexes, gender, the social relations of the sexes, straight thought). - This knowledge regarding gender is not taken into account by sports governing bodies because it belongs to the field of the social sciences. The hierarchical organizatio n of knowledge is a product of a history of	

					while many social scientists are women. - Dutee Chand was asked to not only prove that the IAAF studies were wrong but also to scientifically prove that testosterone is not a direct indicator of athletic performance. Dutee Chand's team brought up the argument of the complexity of gender difference and the causality of sports performance. Meanwhile, the IAAF came up with their own investigations. The arguments put forward by Dutee Chand's team were considered by the CAS panel to be nothing but unproven assumptions, speculation, and hasty conclusions. The social science researchers involved were discredited as merely over-	delegitimizing of knowledge, which, particularly in the social sciences came about due to the oppression of the researchers within these fields. Faced with leading governing bodies, those who carry this knowledge experience epistemic injustices and an enterprise of delegitimization.	

					interpreting medical data which do not fall within their field of expertise. All this took place despite the fact that a member of the IAAF team was found to have published data and an analysis on testosterone and sports performance that turned out to be false (admitted by the researcher). K.Karkazis' articles on bioethics were considered to be "sociological opinions" not resulting from real clinical knowledge. - The IAAF arrived at the trial with a material advantage (and therefore a scientific advantage) because of its ability to finance research on its own terms. Compared to Dutee Chand, the IAAF also has incomparable human resources as a		

					result of the sheer amount of data that they hold on their competitions (especially through the World Anti-Doping Agency) and which they have access to. - The IAAF's strategy was to say that they do not seek to find out who is a man and who is a woman but rather that they seek to make a distinction between women in terms of access to sport. However, the author highlights the fact that the IAAF has never sought to medically supervise the male category. This strategy allowed the IAAF to transform the debate and the framework, making it seem purely medical. Additionally, an IAAF witness defended the regulation by stating that it would keep men		

					out of the women's category. This suggests the real motives behind the regulation. Overemphasizing the medical/health aspect of a supposed pathology is simply a strategy. Dutee Chand has been subjected to a lot of violence from the medical institutions within the framework of this regulation. This shows that the wellbeing of the women who are subjected to this regulation is not taken into account. Drawing upon regulation as thought has the effect of reinforcing the idea that "normal" women would be weaker, more vulnerable and more in need of protection than women who fall outside of this framework. Pape insists		

					upon looking at regulations not only from a biological perspective but also from political and social perspectives. This framework of analysis allows us to highlight the way in which the same dialogues and myths about a social fact are reconfigured with new biological data to replace the old ones that have been proven to be obsolete.		
Ritz, S. A	2017	Theoretical discussion, sex variable and biomedical research		No	In this article, the author explores the limitations of biomedical research that attempts to take into account the variable of sex without questioning it or worrying about the consequences of such hasty generalizations. - The definitions given in biomedical	This article highlights the limitations of taking the sex variable into account in medical research. It is clear here that some research allows itself to make generalizati	Terminology: does not refer to trans people but refers to the "cis-normative gender binary" **320: Limitations of the designation of the categories "male" and "female"** "We make use of the labels "male" or "female" as though we are

					sciences of the notions of sex/gender are limited to an understanding of sex as being based on biological data and of gender as being based on social data. However, research in gender studies, in particular the feminist critique of science by Anne Fausto-Sterling, quoted here, has shown that sex is dependent on gender and that the gender system modifies so-called biological sex. The significant social aspect presents itself as one of the major limitations associated with trying to draw conclusions about sex/gender based on the observation of cells. - The conditions under which cells develop within the laboratory environment	ons about differences between men and women based on a single variable that is often incomplete and erroneous. There is value in developing a broader understanding of sex/gender in biomedical research to avoid these pitfalls.	stating a singular biological reality, but really we are invoking an entire constellation of characteristics that, at best, have a reasonably strong correlation with one another. In doing so, we are engaging in "interested instances of power ... with real material consequences " (Barad 1996, 182) for how we understand the impact of sex on health." **320-321: Impact of gender stereotypes on research** "The upshot is that in treating sex as a unitary dichotomous variable and comparing females and males, we are allowing stereotyped thinking about sex and gender to substitute for

					differ quite considerably from the conditions of development that are actually present in a sexually differentiated and social body. 1) Obtaining cells from human tissue is complicated. The number of cells extracted tends to be reliable. Beyond the sex variable, there are also many other characteristics that come into play and these also need to be taken into account. 2) It would be better to talk about what type of sex we are talking about (i.e., whether we are talking about sex in terms of gonads, genitals, chromosomes, etc.) rather than drawing conclusions about an entire category from weak and incomplete data. 3) The production of hormones within		the mechanistic understanding that is presumably the goal of experimental research, doing a disservice to people of all genders with respect to our understanding of biology and health"

					the endocrine system can be dependent on the social context, on physiological and reproductive functions, or even on age. The levels of hormone production thus vary according to the internal and external context. In the laboratory, cells are isolated from this social, hormonal, nervous, etc. context. The reactions we see in the lab are therefore distinct depending on whether we are looking at an *in vitro* situation or an *in vivo* situation. When men and women are separated under experimental conditions, the variable of sex is taken as a whole without taking into account its complexity and the different dynamics that constitute it. A problem also		

					arises in that when we look at one component of sex, we assume that all the others are aligned. Moreover, the biological categories attributed to men and women are not dimorphic. The conclusions drawn cannot be generalized; they are, at best, trends of observed correlations that do not take into account every factor. The impact of social factors is very frequently neglected. - We must recognize that all knowledge is situated, constructed, and biased. Even if the cells that are taken come from donors whose sex is known, this fact does not constitute a functional variable in the research. For example, some research examines the		

					effect of estrogen on cells as a female variable, even though all bodies produce estrogen. It is not possible to isolate the biological and the social when one influences the other and vice versa.		
Sullivan, C. F	2011	Theoretical discussion of rules and regulations, supervision of the bodies of sportswomen		No	In this article, the author reviews the main regulations that have marked the history of the medical supervision of women's bodies (cis, trans and/or intersex) by sports governing bodies. - The concept is based on the preconceived myth that all men have a physical advantage over all women (hegemonic masculinity). To maintain this system, women must remain inferior to men at all costs. - Different markers have	The author examines the regulations governing trans people's participation in sports (with a focus on trans women in particular). She situates this within the framework of the history of the femininity test. She highlights the limitations of these tests and the disastrous consequen	Terminology: Transsexual or transgender

					been used throughout history to identify the sex of sportswomen (genitals, chromosomes, hormones). Each test has been built on the assumption of unproven sexual dimorphism. - Systematic gender testing is a product of the Cold War; the first test of this kind was administered in 1966 at the European Athletics Championships. All participating athletes were required to undergo a genital examination that was humiliating and degrading. This was followed by genetic tests that proved to be non-functional; the sports world learned of the existence of intersex conditions. Maria Jose Martinez Patino, who had obtained a	ces that such tests have had on sportswomen. Page 409: The author highlights the lack of considerati on in the literature of the increased risk of injury that trans people and particularly trans women may experience: "Transathle tes who carry "male" skeletal structure and height on "female" musculatur e have been found to be more prone to injury (Carlson, 2005)." This is one element from a response to the Sutherland (2017) article.	

					certificate of femininity during the first phase of testing, was outed as being intersex following a chromosomal test. Her certificate of femininity was subsequently revoked as a result. The fact that she finally presented as having an insensitivity to androgens despite her karyotype led the federation to readmit her 3 years later and to permit her to compete. However, she was never able to regain her sporting level due to the violence she experienced at the hands of the sporting and medical institutions which forced her to stay away from the field. - The 1990 recommendations to stop femininity testing were not accepted. A second phase of		

					chromosomal testing was introduced. As of the year 2000, these femininity tests are no longer systematic. They are carried out on the basis of doubts about someone's sex based on visual examination; therefore, their usage is based on external criteria of cis-heterosexist femininity. - The author takes the 2003 Stockholm consensus as a starting point and shows that factors such as whether or not a given country's legal system permits a person to change their civil status, how easy/difficult it is to access hormones, and how easy/difficult it is to access surgery all depend on the social and geographical position of the athletes. The 2-year transition		

					period is arbitrary. Far from having a physical advantage, trans people may suffer injuries as a result of their transition and may experience health problems related to medical interventions. - The Gay Games applied very discriminatory rules (until 2018). The 2004 World OutGames in Montreal used the 2003 IOC rules. Most federations use rules similar to the IOC rules. - The regulations in force now focus on hormonal levels under the impetus of the IAAF, which calls testosterone a "male" hormone, even though all bodies produce it.		

Pape M.	2019	Theoretical discourse analysis	CAS ruling, Dutee Chand vs IAAF, discourse analysis	No	- Exclusion of certain knowledge by sports governing bodies as a result of scientists' restricted definition. This makes it impossible to see the power dynamics at stake in the creation, maintenance, and legitimization of the regulations. - Instead of considering non-dimorphic findings as being part of the diversity of human bodies, these findings, when they manifest in women, are pathologized and excluded from the studies. When scientific investigations are proposed by both sides (e.g., Chand vs. IAAF) only peer-reviewed studies that provide a narrow definition of testosterone and its impact	This article demonstrates the hierarchy of knowledge at work in the legitimization/delegitimization of certain knowledge produced on testosterone. It worth noting that the IAAF regulations stand in line with the pathologization of women's bodies. Indeed, the author demonstrates that when women's bodies fall outside of the norm, such women are considered to be unwell. However, when men's bodies fall outside of the norm,	Terminology: transgender women

					on the body are considered by the CAS panel; namely, studies conducted by life scientists. - The production of knowledge is dependent on the material and symbolic resources that are allocated to it. Moreover, the CAS asked the IAAF to provide new evidence, siding with the IAAF despite having no evidence, and basing this ruling solely on a hunch that they would be able to provide supporting evidence. Conversely, Dutee Chand was not given the opportunity to come back with new evidence.	they are just considered as being out of the ordinary. The material and symbolic resources of knowledge production are to be taken into account in the evaluation and considerati on of different knowledge that is published on the subject.	
Anderson E. and Travers. A	2017	Introduc tion to their book *Transge nder athletes in competi*	/	/	In this introduction, the authors develop the idea that trans athletes highlight the flaws of the sport categorization	Caitlin Jenner is misgendere d from the first paragraph	

		tive sport			system by refusing to accept the categories determined by the sex/gender system.	Shanti Sounarajan is referred to as a trans woman when at the time of the book's publication it seems quite clear that she is a cis woman who has been excluded from competitio n because of her intersex condition.	
Teetzel S.	2017	Semi-structured interviews: n= 10 (5 trans and 5 cis)	**PICO where relevant: Population, Intervention, Comparator, Outcome) Population**: 10 respondents: 5 cis women, 3 trans men, and 2 trans women. **Intervention:** Semi-structured interviews about regulations governing the participation of trans	No	In this article, the author interviews trans and cis athletes about the rules and regulations that govern trans athletes' participation in sports. ***Uncertainty regarding where the science is at*** Participants struggle with delineating what would count as a physical advantage. The cis participants have almost no knowledge of the endocrine	There is little socio-demographic data on the participants, which limits the analysis. It may be difficult for active trans athletes to criticize the rules because of their position in the sport space.	

			athletes in sports. **Comparator**: None **Outcome:**		system. Unlike the trans participants, the cis participants had not previously thought about or been confronted with (and therefore not been forced to think about) the issues surrounding such regulations. The trans participants pointed to the lack of available data and the quasi-systematic exclusion of trans women. The notion of passing seems to be paramount in understanding the differences in access to sport. ***A commitment to some sort of fairness*** None of the participants agreed with the myth that some people would transition just to change their gender category in competitive sports. It is important to		

					take into account class differences and the economic capital needed to take part in certain sports. This in itself is an advantage. ***Connecting inclusion and respect*** One way for trans athletes to protect themselves from transphobic and transmisogynous attacks is to seek refuge in the very rules that place medical limitations on their participation. In line with the results obtained, the author proposes moving away from the concept of fairness and toward the concept of respect. Thus, operating from a place of morality rather than basing decisions on regulations which imply a state of equality		

					that doesn't even exist.		
Vilain E., Ospina Betancurt J., Bueno-Guerra N., Martinez-Patino M-J.	2017	Theoretical article	/	No	The article provides a discussion/contextualization of some of the regulations that trans athletes are subjected to. - There is a long history of men and their institutions banning women from taking part in sports competitions. E.g.: Marathon – women were banned from taking part in Marathon events at the Olympic Games for 84 years. The division between women and men in sport is a product of this history - The authors review the different phases of the femininity tests used in sports competitions. These tests are currently based on external criteria of femininity. For example, Caster Semenya was		

					forced to undergo a femininity test based on doubts about her sex based on her “questionable visual appearance”. - A look at the IAAF and IOC regulations.		
Heggie V.	2017	Theoretical article	/	No	The desire to maintain a framework for the female category predates the systematic implementation of gender tests/femininity tests and dates back to the beginning of the 20th century. During the 20th century, it was mainly FTM transitions (or the possibility of them) that worried sports organizations. This was the case for Zdenek Koubkov, Mark Weston, and Willy de Bruyn. There was a particular panic about the masculinization /virilization of women and the impact that		

					sport would have on women. This argument was also used to justify limiting or even prohibiting women's access to sport. - Review of the different tests and their failures		
Buhuon	2015	Theoretical Paper	historical summary – review of historical literature on perceptions of femininity in female athletes and/or female sports.	No	Policing of women's bodies is significantly linked to cultural values of femininity. Racism and expectations around the cultural roles of women are a significant predictor of public concern around "fairness of sport" (i.e., athletes presenting more feminine or hiding "masculine" traits). Many of these controls were put in place and established for geo-political	Potential avenue to evaluate perceptions of feminine aesthetic as a predictor for testing/criticism. Well documented history of discriminating against women who do not appear culturally feminine (from a European/ American point of view)	Castors results were not world record breaking, and yet still of significant concern due to public perception. Interesting how comparative advantage is perceived based on the skill and/or ability of the competition. Are women's sports only fair if competition is "less" than men's sports?

					reasons (i.e., 1960's cold war fears "Russian women superiority"). Author suggests that authorities rely on these subjective evaluations of aesthetic and visual assessments and no longer test systematically. Bias exists between North/South (white/coloured) and is used to control not only gender but the "non-hegemonic' femininity of eastern sportswomen.		
Devine	2018	Gender, Steroids, and Fairness in Sport	None, the author is either intellectually disingenuous or is seriously lacking critical thought.	NO	Author concludes that there is a valid parallel between trans-women participation in sport and that of individuals caught with doping	Advantages conferred are not equivalent nor did the author present any evidence to suggest	There is a biologic basis for structural brain differences between trans-women and cis men (i.e. trans women's

					violations returning to the sport pre-maturely or at all. Author does note that binary gender norms should be abandoned. - Author presents idea of tolerable unfairness which is an interesting avenue to consider. - author examines values of fairness in respect to inclusivity. And has reason	as such. Author relies on logically flawed conclusions by establishing “facts” which are not supported by evidence. - I suggest that the conclusions of this article be ignored, however some information within the article could prove to be useful. - Author ignores for example trans-women skeletal changes during puberty which result in a total body mass increase which may act	brain activity matches more closely with cis-women). It would be interesting to see if any research has been done to categorize these biologic differences in terms of differences in core functionality (or population evaluation of body mass etc of trans women if any exist)

					ed argum ents agains t “trans” catego ry in sport as well as forcing athlete s to compe te with birth gender . Author admits that his thesis is speculative but qualified i.e. that even if the flawed basis is proven true it only establishes pro-tanto reasoning. (Reviewer disagrees that even partial “only to extent” pro-tanto reasoning exists.)	differently to a reduction in T (especially in terms of athletic performan ce). - Author assumes trans women exhibit same physical traits as cis-men, this is incorrect due to socio and medical reasons (higher rates of mental health, eating disorders etc). -	
Foddy and Savulesc u	201 1	Time to re-evaluat e	Selective review of literature, no new	No	Author contests that female athletes are	Article mentions that castors	Paper describes two different frameworks

		gender segregation in athletics?	empirical evidence was presented. (recommend rejection)		justified in arguing for exclusion of other women based on a false premise that intersex or trans athletes are still "partially male". Author suggests this could be overridden by relaxing restrictions on doping without addressing any of the potentially negative health consequences to athletes. Author (without proper citations) indicates that men perform at much higher levels of sport despite having access to same levels of equipment, training methods and both work equally hard at training. This point is reoccurring	victory was still not a world record (yet still unacceptable because she is "partially male apparently". This is analogous to an argument that elite athletes should not be allowed to play recreational sports because they would dominate. 1. The differences between sexes is not based purely on gender, it is because height and weight adjusted men still outperform women (almost entirely because	for evaluating sport. 1) to identify natural potential of individuals, therefor genetic variation is desired. And 2) reward the hardest worker (which is currently obviously untrue).

					throughout literature, so it needs to be addressed (points 1-4 in next column). 57% of serum testosterone between individuals is caused by genetic factors (Ring et al., 2005). (suggestion that This suggests a strong environmental factor to serum testosterone levels as well. And should be examined) Michael Phelps example of Marfan's syndrome, arm span (does not include oxidization advantage however) "naturally occurring" seems to only impact women's sports and men are not	women carry higher body fat % and therefor less lean muscle mass). 2. Training and equipment is optimized for male performance; recent study suggests that women should train on different interval sets (higher rep) for optimal strength gains. 3. "working just as hard" ignores social realities which disadvantage women from being able	

					regulated as such.	to dedicate time towards their sport. 4. Confirmation bias towards lack of permutation tests (see women Chess player rankings)	
Genel	2016	Transgender Athletes: How Can They Be Accomodated?	Select review of existing literature	No	The Author does not present their own conclusions, however they do mention some interesting details. 1) Many of these limit requirements face difficulty when assessing intersex individuals. 2) Likely there will be more trans-athletes being included in interscholastic sport.	the 10nmolL threshold is arbitrary and is not set on any population level data by cis-women. Further, it is not clear that individual variation within testosterone limits is a clear indication of performance advantage, let alone an “unfair”	

					A Key point brought up in this paper is reference to testosterone supplementation by trans women with their gonads removed. As their testosterone falls below cis-women levels. However this is currently not permissible under WADA guidelines. Due to this a Canadian cyclist filed suit in Canadian court that she should be able to maintain testosterone levels up to 5nmolL. Worley v Ontario Cycling Association, Interim Decision, Human Rights Tribunal of Ontario. [cited 2016 October 28]. Available	advantage in all sport (some evidence is present re: intersex sprinters)	

					from: http://www.canli.org/en/on/pnhrt./doc/2016.tp952/2016hrto952.h.		
Gill-Peterson	2014	The Technical Capacities of the Body: Assembling Race, Technology and Transgender	N/A	No	The author presents no valid qualitative or quantitative evidence nor draws any useful information which to draft this report on. Paper discusses competing ideologies of race/technology/ecological impacts and gender.	Recommend removal from list.	
Handelsmanm, Hirschberg, Stepane Bermon	2018	Circulating Testosterone as the Hormonal Basis of Sex Differences in Athletic Performance		Unknown	Author argues that circulating testosterone is the most important marker for athletic advantage because of increasing muscle mass, strength, bone size, density and hemoglobin.	Author uses terminology like “bone size” as if this is different from height or frame size, neither of which are an establishe	Literature is very dense and requires an additional reviewer to provide some more specific background and verification of points.

					Androgen sensitivity for men with testes removed may play a significant moderating role.	d basis for discrimination. Further bone density is not a retained advantage as black female athletes have higher bone density than white male athletes (study find, look Hilton response.) Rates are used from cancer patients, and likely are not representative for elite athletes. Paper makes inaccurate conclusions on the initial performance advantage	

						s of men vs women.	
Hargreaves	2012	Gender Equality in Olympic Sport	Is a review of womens participation in sports, no new evidence presented	No	Sport has been an integral part of modernization in GCC countries and in particular Arab women have been able to leverage this to become agents of change. Author argues that sports reflects and influences cultural values.	This may form a basis for inclusion of transwomen and DSD women in sport irrespective of advantage. Representation matters no only to individual health but also to societal value changes as sports has an ability to change societal perceptions of equality.	Limited scope "story"
Harper et al.,	2018	The Fluidity of Gender and Implications for the Biology of	Survey analysis	Yes – Lead author	Paper examines survey data from three different events 1) the 12th international congress of the sports	Paper is interesting insight into the thought process of academics, but I do not believe it has	Can illustrate some of the epistemological challenges of the subject.

		Inclusion for Transgender and Intersex Athletes			medicine association of Greece; 2) public lecture at the university of Brighton; and 3) the 2018 spring conference of the British association of sport & exercise medicine (BASEM). The author shows that there exists a wide spectrum of opinion when it comes to testosterone regulation for both DSD and transwomen. This range includes individuals who are concerned with doping, innate biological advantages among others.	relevance for this study.	
Henne	2014	The "Science" of Fair Play in Sport: Gender and the	Social and historical analysis of the issue.		Women's sports has a lengthy history of being categorized for cultural and political reasons.	Author has solid arguments on the basis for what sports should	Many Authors reject gender verification on the grounds that it is degrading to

		Politics of Testing			Author argues that gender verification is not only degrading to women but it upholds myths around gender that form the basis for fair play. While testing has found results in gendered differences when it comes to sport, they are based on an idea that biological sex should align with culturally constructed myths of gender. These are used "under the guise of leveling the playing field for female athletes". The author argues that DSD regulation seeks to preserve the idea that "woman is inherently distinct from and less able	strive to become. I.e. independent of cultural myths around gender. However, when discussing trans participation in sport there exists some evidence of performance related data which suggest potential issues around safety and fairness in sport for identification only policies. This very may well be socially constructed artifacts, however given that we are informing policies	women (Skirstad 2000)

					than man.“ Fair play is rooted in values of amateurism which are no longer practically relevant for most sport. Similar arguments were put forth in questioning the validity of using prosthetics in sport (Pistorius)	for where society is at now, within Canada, reasonable restrictions should not be rejected out of hand out because of a contradictory ideological stance.	
Ingram, Thomas	2019	Transgender Policy in Sport, A Review of Current Policy and Commentary of the Challenges of Policy Creation	Review	No	Author looks at the history of trans participation of sport from high school to professional levels. There exists limited scientific data as it relates to performance advantages held by transwomen in sport, further women’s sport is poorly defined (other than separate from men’s). Author suggests it is difficult to	Paper references (table 3) strength gains and losses which are inaccurate. In particular the decrease to muscle mass and strength is largely unknown and the interval stated should not be used to inform policy.	This article leads to an entire section which should relate to how policy should be constructed to enable it to be more equitably accessed. I.e. not having sports federations monitor their athletes, but rather have policies that are behind a physician recommendation?

					make inclusive policy that is fair but accessible. Author concludes that ongoing study and input is required by the medical and scientific community in the topic.		This raises issues of compliance.
Klarkazis, Jordan-Young	2015	Debating a testosterone "sex gap"	Article, not peer reviewed (I believe).	No	The author states that DSD women and women with naturally occurring high levels of T must be included when considering what is fair in sport. And that a conclusion drawn decades ago was those "who were raised as girls and classify themselves as female should not be excluded from competition as women" The basis for these arguments is social and ethical around how we	The arguments made are logical, however as it relates to transgender individuals, we have no evidence to suggest that pre-treatment transwomen have similar performance and strength profiles of DSD women or women with high T levels. As a result, there may	Daegu study "there is no clear scientific evidence proving that a high level of T is a significant determinant of performance in female sports" The testosterone rule—constructing fairness in professional sport https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5570685/

					classify human diversity.	be a basis for requiring some form of HRT, however this is still largely unresearc hed.	

*None of the literature talks about performance advantages of men vs women in terms of either resourcing (men's teams receive more resources for training, and training is optimized for male bodies (kin study available). They also do not include any basis for permutation (instance rate and variation among edge-scenarios – look at chess participation rates and its impact on performance rates (https://en.chessbase.com/post/what-gender-gap-in-chess) for elite athletes.

Grey Literature

Table 12 Detailed review table of grey literature.

Author(s)	Year Country	Kind of Study and/or Sample	Self-identified trans researcher(s) lead and/or trans research team members?	Key Conclusions	Key Reviewer Criticisms	Other notes
World Anti-Doping Agency (WADA)	Sept. 2019	/	/	- Regulations for obtaining a Therapeutic Use Exemption (TUE)		**3: Composition of the medical file** "All TUE applications must include

				- Provide a detailed medical file and the rules of the sports federation		a report from a healthcare professional who treats transgender individuals. This report must provide details of the athlete's medical history, including whether the athlete has undergone any partially or fully reversible physical therapy. This document should be accompanied by an endocrinology report from the endocrinologist who initiated the hormone therapy as well as a surgical report, if applicable. A full medical evaluation is required prior to the initiation of any

						treatment to determine the level of individual risk associated with the various treatment options."
World Health Organization (WHO)	May 2019	/	/	- the WHO takes a stand against the 2019 IAAF regulation that requires women to medically reduce their natural testosterone levels		**WMA President Statement:** WMA President Dr. Leonid Eidelman said: 'We have strong reservations about the ethical validity of these regulations. They are based on weak evidence from a single study, which is currently being widely debated by the scientific community. They are also contrary to a number of key WMA ethical statements and

						declarations, and as such we are calling for their immediate withdrawal'.
CCES	2016 Canada	/	/	- best practice (respect for the privacy of players, right to freedom choice of first name/pronoun/gender, providing information, the inclusiveness of rules, being attentive to the needs of trans athletes, training/prevention, access to toilets and lockers for all, proposing uniforms in accordance with gender expression) - There is no tangible evidence about the effect of hormones - Recommendation: gender identity regulation. If other criteria apply, then it is up to the federation to prove legitimacy.		**20: About hormone levels in regulations** "Unfortunately, neither the 2015 IOC consensus meeting nor the NCAA policy are grounded in direct scientific evidence of hormone levels having a significant long-term impact on athletes' performance. No research has been done in this regard " **20 : Elite recommendation** "Based on this context and the evidence that is available,

						the Expert Working Group has reached the conclusion that transgender athletes should be able to participate according to the gender with which they identify, regardless of whether they have undergone hormonal treatment. If a sport organization can prove that hormonal treatment would be a reasonable and bona fide condition (meaning a required response to a genuine need) in order to create a level playing field in high performance sport,

						exceptions may apply. ”
Jeré Longman	USA	Journalistic article, opinion piece	No	Argument: The discriminatory treatment of C. Semenya. Many champions have different physical advantages that are not subject to as much regulation, violence, and exclusion.	- Statement from the IAAF (P. Weiss) vs Semenya - Statement by K. Karkazis on bias and stereotyping - Example: Kenyan high altitude training - Example: the body size comparison between K. Durant and B. Griner - Example: E. Mantyranta (who had a genetic mutation causing him to produce a higher than	

					average amount of hemoglobin)	
Lenskyj, H. J. (only chapter 4)	2018	Theoretical article	No	- In countries such as Canada and Australia there have been political debates about making sports exempt from having to comply with anti-discrimination laws. - The media's treatment of Laurel Hubbard makes it seem as if she made the decision to transition suddenly in a bid to win competitions. This demonstrates an ignorance of the lived experiences of trans people. **Kristen Worley** - The athlete's suppressed testosterone levels had an impact on her body, resulting in muscular atrophy,		**134: Quote from K. Worley on the CCES evaluation** "As she explained, 'I had to sit in front of a panel of men, and in conference calls with men I had never met [...] [answering questions] about my physiology and about the reasons why I wanted to compete in sport.' Her gynecological information was shared among male sports leaders as well as doctors. As she stated, 'It is a form of interrogation, rape and humiliation' (cited in

				which is what distanced her from fellow competitors in her sport. - She applied to the CCES to take testosterone in small doses for health reasons. The CCES took 3 years to grant her permission. This agreement was only valid for 1 year. She had to provide her blood test results every 2 years. WADA rules require a maximum of 2 tests per year. - 2011 TUE application to CCES: She underwent a major medical and psychiatric evaluation that the athlete found distressing and damaging. A lack of respect was shown with regard to her personal data. - After a legal battle, Kristen did not obtain a		Brown, 2015). ”

				license from the UCI. **"Objective science"?** Biases that may appear in research: - Considering sport as a space that is reserved for men and masculinity - Not taking into account biological and social constructs - Assuming that testosterone gives athletes a physical advantage. Confusing causality with association.		
Pieper, Lindsay Parks	2016	History book of the femininity test in sports competitions (Introduction)	No	**Introduction** - The IOC often uses the concepts of gender and sex interchangeably, especially between the years 1968 and 2000. - The discursive change between "sex testing" (1968 to 1976/80) and "femininity testing" (1976 to 2000) (« contrôle de sexe » and « contrôle de féminité » in		

				French) shows that biological data are not the only things that are being evaluated. - Cold War: sport and gender control = confrontation surrounding sex (even if this did not systematically exist prior to the Cold War). The new "other" since 1990 = racialized women from the continents of Africa or Asia. - Problem with the dialogue around *fair competition* = this is a goal that is not achievable anyway, but it is mobilized for the purpose of excluding certain populations.		
Wente, Margaret	May 2019	The Globe and Mail. opinion piece		- trans women = intruders - men are biologically superior to women - trans women = cheaters - the advantage given by testosterone is insurmountable	- erroneous preconceived notions about testosterone with no basis - suggests that there is a trans movement that is	

					attacking women - Sharron Davies' quote against trans people	
Laurel Westbrook	2016	Theoretical article	Non-binary (they)	An article that attempts to trace the history of the terminology used to refer to trans people. Also attempts to think about trans people in relation to categories of sexuality.	- Trans people are thought of almost exclusively through the prism of gender subversion. This approach is flawed; it obscures the social relation of the sexes and the consequences of this on the lived experiences of trans people. - The article highlights, without any real source or justification, both the beginning of the use	

					of the term *transsexual*, pinpointing the first case of its usage in 1952, as well as the case of Christine Jorgensen. The conclusions drawn not only seem precarious, they also underline the ciscentrism of the article. What is presented is a cis interpretation of the terms that are used by cis people to refer to trans people (but without making this point of view explicit, of course).	

					The article takes an essentialist view of sex and gender by making a distinction between the term transsexual (defined as the act of changing one's biological sex) and transgender (defined as the act of changing one's gender). However, if the sex of an individual is determined by their gender, we can just as easily say that a person has changed their sex (or gender) regardless of the type of transition	

					(whether it be social, medical, institutional) that has taken place. The author discusses the fact that the only word currently used to describe being attracted to trans people would be the slur *tranny chaser*. She goes on to propose potentially less offensive terms without taking into consideration the power dynamics that come into play in the fetishization of trans people by	

					cis people. She even goes so far as to propose a new meaning for the word *transsexual*, suggesting that this term could be used to refer to individuals who are attracted to trans people. In proposing a new meaning for this term, the author is furthering the cis appropriation of terms relating to the trans experience. A portion of the trans population has already reclaimed this word.	
Pape M.	2020	Qualitative semi-	No	- Men at the elite level in athletics	This article allows us	

		structured interviews n=62, with athletes, coaches, staff members, managers, officials, and federation representatives, media professionals, academics and activists between 2009 and 2016 = inclusion criterion: involved to any extent in the implementation of the testosterone regulations in the female category.		have hormone levels that are equivalent to the average hormone levels seen in women - Ignorance = an active process whereby it would have been possible to find out about a particular topic but where this knowledge has not been sought out or obtained The 3 types of ignorance: 1. Disinformation Most athletes were in favor of the IAAF rules. But most of them did not really know much about what the stipulations laid out in the rules consisted of. The majority think that this is an ethical issue and not a scientific debate. Many did not know the history of the femininity test (one person proposed -	to examine the process of ignorance observed in members of the sports movement in cases that involve athletes with an endogenous testosterone level that is higher than the average level for women. The failure to inform oneself, to avoid confronting certain information, to question the actions of the federation, and to train/educate people about the discrimination experienced by these	

				without knowing that one had been done and without knowing the problems posed - to carry out a chromosomal test). There was a lot of confusion about the terms used in the debate such as the term "hermaphrodite". Some athletes were referred to as men. Pathologizing intersex athletes. 2. Ideology The formulation of the regulations = an enclosed and private space for the construction of knowledge. Preconceived ideas about the issue being discussed affect how the regulations are established in the first place. Most respondents strongly believe that testosterone levels have an impact on the differences in athletic performance.	athletes is socially situated. Although the author accurately shows the three types of ignorance at play, the social positions of the different surveys could have been better taken into considerati on, in particular, it would have been helpful to look at how the different power dynamics have an impact (notably where race, gender, class and nationality are concerned) .	

				Many were incredulous and were surprised that the Court of Arbitration for Sport (CAS) suspended the regulation in 2015 due to a lack of scientific evidence. Confusion between endogenous and exogenous testosterone. Some chose to ignore the glaring lack of scientific evidence and were instead guided by their beliefs/stereotypes. This was particularly true for those in charge of formulating the regulations. 3. Avoidance Some federation workers who were contacted for an interview said that this was not their area of expertise and referred the interviewer to the federation's physicians. An official who tried to get more	Even though cases involving trans athletes are not mentioned, it can be observed that these mechanisms are also at work in such cases.	

				information and came up with evidence that the rules were not working at the IAAF was removed. No questioning of the rules; coaches placed their trust in the IAAF. Fear of backlash if the rules are challenged. Silence also forms part of the social position; some people have benefitted from the fact that the regulations remain in place, even though their underpinning is not scientifically correct. The federations were involved in maintaining the silence of the athletes. Some advised the athletes just to answer that the 800m did not concern them.		

Appendix C: Scoping Review Yield

Figure 2 Summary of scoping review yield from June 2021.

#	Éditeur	Base de données	Types	Résultats
1.	(ELSEVIER)	Embase	Sciences biomédicales	96
2.	(OVID)	Medline	Sciences biomédicales	263
3.	(ProQuest)	PAIS International)	Sc.p olitique	16
4.	(OVID)	PsycINFO	Psychologie	193
5.	(ProQuest)	Sociological Abstracts & Social Services Abstracts (2)	Sciences sociales	121
6.	(ProQuest)	Sport Medicine & Education Index	Sciences du sport	169
7.	(EBSCO)	SportDiscus	Sciences du sport	328
8.	(CLARIVATE)	Web of science, Core Collection	Multidisciplinaire	342
9.	(EBSCO)	Women's Studies International	Femmes	49
10.	(ProQuest)	Worldwide Political Science Abstracts	Sciences politique	19
			TOTAL	**1,697**
			Doublons	**703**
			1er tri	**994**

Appendix D: Hilton & Lundberg (2020) Detailed Methodological Concerns

Methodological Concerns Regarding Hilton & Lundberg (2020) Transgender Women in the Female Category of Sport: Perspectives on Testosterone Suppression and Performance Advantage

This is a condensed detailed analysis of the methodology and integrity of Hilton & Lundberg (2020), especially important because of the impact of this single paper on sport policies regarding trans women. The paper has several notable weaknesses which are never addressed, which are categorized and listed below. It is a reasonable conclusion that this paper draws from a prior ideological position seeking to discredit and exclude transgender athletes and misuses the available literature to justify this position. In other words, this is an argumentative paper presented as a scientifically rigorous review.

Author bias:
The primary author, Dr. Emma Hilton, does not have a background of sports medicine, and none of her prior publication credits are on topic with sports performance, transgender health or any kind of exercise. Co-author Dr. Tommy Lundberg does have a background in sports science.

Unfamiliarity with trans women as a population:
Use of terminology 'Biological Males'
Use of cis-men population comparators

Drawing false conclusions:
Hilton & Lundberg do not appropriately review the available literature and draw false comparisons between men and women athletes. As a specific example, the authors state "This Olympic weightlifting analysis reveals key differences between male and female strength capacity. It shows that, even after adjustment for mass, biological males are significantly stronger (30%) than females". This is a disingenuous statement as:

1. Sport (historical and cultural context aside) is segregated by gender because men produce higher strength in terms of total mass. Because women have a higher percentage of body fat mass in comparison with lean body mass, we segregate some sports in respect to both total mass and gender because it allows for an approximate comparison of total lean body mass.
2. In sports without weight categories, height and weight do not meet the threshold to be considered characteristics involved with "intolerable unfairness." Advantages due to being taller or heavier in these sports (e.g., basketball, volleyball, rugby) are not currently considered "unfair". The average NBA player, for example, is nearly 10 inches taller than the average man and 40 pounds heavier.
3. Male and female muscle is the same strength when comparing equivalent cross section/size (Costill et al., 1976; Schantz et al., 1983).

4. Much of the increased strength of cis-men compared to cis-women can be explained by height differences. When adjusting for height and fat free mass, this relative difference disappears (Castro et al., 1995; Harms, Cooper, & Tanaka, 2011).
5. Lean body mass increases with height for both men and women (Forbes, 1974).
6. It is unsafe for cis-women to attempt to achieve cis-male levels of fat (Nazem & Akcerman, 2012). This affects speed and endurance activities due to having excess non-performant mass.

The assumptions employed and conclusion posed by the authors is therefore not supported by evidence found in the literature. The authors systematically use adjustment for mass instead of fat-free mass which leads to significant errors when comparing population groups. This argument is of key importance as transgender women athletes undergoing HRT increase their estradiol, affecting total body fat percentage, and also significantly reduces testosterone, reducing muscle mass, red blood cell count and other factors important for athletic performance. (The authors appear to be aware of the distinction between total mass and fat free mass as shortly after they state, “even when expressed relative to fat-free weight, VO2(max) is 12-15% higher in males than in females”.)

What is needed to have effective comparisons is:

1. Comparing trained athlete cohorts.
2. Body composition (fat-free mass %) – affected by testosterone.
3. Height-matched control groups.

Omissions and errors in Table 4:

In Table 4 of their article, Hilton & Lundberg (2020) summarize their findings from available literature, categorizing differences between men’s and women’s athletic performance. This table has many errors, some of which demonstrate the authors’ disregard for scientific objectivity. In addition, there were omissions of contradictory data from this table. These errors and omissions are listed below.

1. The reference group the authors employed compares “average cis women” to cis-men, without adjustment for height or weight. This is significant since cis men are, as a population, taller than cis women, and we would expect to see similar results in comparing any taller group to a shorter group (for example, comparing five foot four inches tall cis women to five foot ten inches tall cis women).
2. Authors state that “grip strength provides an excellent proxy measurement for general strength in a broad population”. However, this is distinctly incorrect (Yeung et al., 2018). Grip strength is largely correlated with hand size rather than strength due to gripping testing device easier (Alahmari et al., 2019).
3. The authors cite a study whereby testosterone-suppressed untrained transgender women see an increase of lean mass (4% leg and 2% overall) after an intense 8 week training cycle. However, in doing so, they omit Roberts,

Nuckols, & Krieger's (2020) findings that untrained females also show high capacity to build muscle mass especially in upper body strength. The authors also do not show the relative strength compared to trained female competitors - a more appropriate comparison group - nor do they include that their control group without testosterone suppression gained significantly more mass and a 400% greater increase to isometric strength. The authors additionally omit that trans women participants failed to gain any noticeable gains to isometric strength. Yet despite these observations, the authors conclude "endogenous testosterone is of paramount importance for the muscular adaptation to strength training."

4. They claim the 12 months hormone suppression as determined by the IOC is insufficient by using data where hormone suppression was present for less than two months.
5. Pelvic width comparison is used as a measure, but studies show that pelvic width difference, including q angle, does not have any benefit for athletic ability (such as moving or jumping); gait differences, lift ability and risk to injury also are not meaningful as a result of q angle (Bruton, O'Dwyer & Adams, 2013; Hertel, Dorfman & Braham, 2004; Kernozek & Greer, 1993; Thomas, Corcos & Hasan, 1998; Nguyen et al., 2009; Sigawrd & Powers, 2006). This includes a study by Sigward & Powers which was referenced by the authors as leading to increased injury in athletics, but the original paper states "No differences in kinematics were found."
6. Bone density was used extensively as evidence of the advantage trans women retain. The claims were unsubstantiated, with no citations to demonstrate bone density as a performance enhancer.
7. The authors argue that larger lung size is a retained advantage. However, they do not adjust for height and ignore studies which have demonstrated that lung size is not a good predictor for sport performance. The differences are due to respiratory muscles enhancement, not lung size (Degens et al., 2019; Hopkins et al., 2018). These findings are misrepresented in the table with the conclusion that "Respiratory function, pulmonary ventilation (maximal)" are significant, when they are not. Specifically, "MBC is not likely to be an adequate physiological measure of the competence of the respiratory system in strenuous work and should be regarded rather as the biomechanical limit of the possibilities of the ventilatory apparatus" (Breslav, Segizbaeva, & Isaev, 2000). Or that it is not a limiter for exercise "After differences in lung volume are acconted for there is no intrinsic sex difference in the DLco, Vc, or Dm response to exercise" and "together, these data suggest that the pulmonary capillary blood volume response is proportional to lung size and is adequate to meet individual oxygen demand during exercise" (Bouwsema, Tedjasaputra & Stickland, 2017). The

limiting factor in endurance sport however is oxygen carrying capacity of blood (red blood cell count which is affected by hormones dramatically) and heart muscle (Fomin et al., 2012; Åstrand et al., 1964).

8. Hemoglobin (red blood cell count) is drastically affected by HRT, falling in cis women's range after 6 months (SoRelle et al., 2019). This is largely ignored by Hilton & Lundberg.
9. Hilton & Lundberg misrepresent lean body mass of trans-women throughout Table 4 by assuming baseline strength levels are comparable to cis-men. But Van Caenegem et al. (2015) - whom they cite elsewhere in the paper - show that trans women as a population start with far lower muscle mass. This means that the reductions recorded in Table 4 are mostly "on top of" the already reduced population level in comparison to cis-men.
10. Table 4 reports absolute values for Wiik et al (2020) instead of the published height adjusted levels.
11. Hilton & Lundberg exclude the female reference values from Fighera et al (2018) in Table 4, presumably as Fighera et al.'s (2018) conclusion was that appendicular lean mass was similar among trans and reference women, and lower in trans women when compared to cis men - a point which contradicts Hilton & Lundberg's argument.

The authors do not report on advantages that women have over men, which are salient to their argument and conclusion:

1. Endurance is higher and recovery is quicker in women than in men (due to higher proportion of type 1 muscle fibers; Haizlip, Harrison & Leinwand, 2015). This performance advantage is important, since individual variation is higher than the variation between genders, and individuals with high level of type 1 muscle fibers gravitate towards endurance sport.
5. The authors suggest that men outperform women on items such as flexibility, which is not supported in literature (Rene', 1984).
6. Women have increased glycogen sparing fat oxidation during endurance exercise (Tarnopolsky, 2008).
7. Women experience higher perfusion, ECV and MBV at stress(Nickander et al., 2020).
8. At a population level untrained cis women outperform men with balance (Torres, Reis & Abreu, 2014).

Each of these pieces supports the claim that the Hilton & Lundberg article is an argumentative essay, but it has been interpreted as a scientific review, with severe impacts on trans women's participation in elite sport.

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Appendix E: List of Some Canadian Organizations Who Have Trans Inclusion Policies at Competitive/Elite Levels

These Canadian sport organizations' policies take different approaches to including trans women, some choosing to focus on accepting all athletes' embodied strengths to be celebrated, - including trans women's - without restrictions, and others taking a narrower approach to defining what kinds of embodiments are permissible.

- Quidditch Canada
- Rugby Canada
- Ringette Canada
- Skate Canada
- Ultimate Canada
- Basketball Canada
- Archery Canada
- Bowling federation of Canada
- Bowls Canada
- Canoe kayak Canada
- Canadian powerlifting union
- Rowing Canada aviron
- Field hockey Canada
- Cycling Canada
- Softball Canada
- Volleyball Canada
- Water polo Canada
- Wheelchair basketball Canada