

REVIEW

Gender identity and sport: is the playing field level?

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This review examines gender identity issues in competitive sports, focusing on the evolution of policies relating to female gender verification and transsexual participation in sport. The issues are complex and continue to challenge sport governing bodies, including the International Olympic Committee, as they strive to provide a safe environment in which female athletes may compete fairly and equitably.

The Olympic motto, “Citius, Altius, Fortius”, succinctly summarises the unending desire for excellence that motivates elite athletes to continually “push the envelope” of human performance. Regrettably, some athletes, blinded by their ambition, have succumbed to the temptation to cheat in an effort to win at all costs. All international sports federations have therefore, by necessity, adopted regulations governing the conditions under which a given sport is to be played, which athletes must (in principle) accept as a precondition of participation in that discipline. Simply put, the goal of such regulations is to keep the “playing field level” so that athletes may compete fairly and honestly. For example, the Medical Regulations of the Federation Internationale de Volleyball (FIVB, the international governing body for the disciplines of volleyball and beach volleyball) prohibit doping as it “runs contrary to the ethics of both sport and medical science, and furthermore constitutes a clear attempt to cheat.”¹

In the present sports culture, cheating has become virtually synonymous with doping, which was defined by the Lausanne Declaration on Doping in Sport of 1999 as “the use of an artifice, whether substance or method, potentially dangerous to athletes’ health and/or capable of enhancing their performances, or the presence in the athlete’s body of a substance, or the ascertainment of the use of a [prohibited] method.”² Although doping represents the greatest ongoing challenge to preserving the integrity of sport, there are other threats to fair competition which international sport federations have been forced to address. In regard to women’s sport, two issues in particular have proven somewhat contentious: sex fraud and transsexualism in sport.

Historically, female athletes have been subjected to a variety of discriminatory and prejudicial practices that have affected their access to sport. For example, women were not permitted to compete in the ancient Olympics, nor were they included when the modern Games were first organised in 1896. In his recent

review,³ Ritchie contends that this omission reflects Pierre de Coubertin’s efforts to exclude female athletes from the Olympic movement. Of course, women ultimately did join the Olympic movement, first participating in the 1900 Paris Summer Games. Those Games featured competition in sex specific events as well as in several “mixed” disciplines, including sailing and equestrian events.

It seems intuitively obvious, given the physiological differences that exist between men and women,^{4–6} that athletes should compete against others of the same sex, unless otherwise specified by rule—for example, in coeducational contests—or in disciplines for which the physiological differences between men and women offer no competitive advantage or disadvantage. In keeping with the ethic of fair play, most international sports federations (including the FIVB) organise their major competitions along sex restricted lines. Unfortunately, segregated competition creates the possibility of sex fraud, and in fact the pretence of competing under an assumed gender is one way by which desperate athletes have, in the past, attempted to gain an unfair competitive advantage over their opponent(s) in pursuit of athletic glory.

This review examines the issue of how organised sport has attempted to safeguard the promise of fair competition offered by the division of disciplines into sex specific events. Specifically, this article discusses the practical consequences of the policies on gender verification and the participation of transsexuals in sport that the International Olympic Committee (IOC) and selected sports governing bodies have adopted in an effort to ensure that the sporting competitions they sanction are fair and that the athletes who compete in them do so on an equal basis.

METHODS

Relevant articles from both the peer reviewed scientific literature and the lay press were identified through searches of the PubMed/Medline, OVID, SPORTDiscus, CINAHL, and Evidence Based Medicine Reviews databases. Keywords and phrases used during the searches included sex, gender, performance, transgender, transsexual, and gender verification. Searches were filtered to the English language. A Google search of the world wide web was performed using similar keywords. In view of the paucity of published research in the area of transgender

Abbreviations: FIVB, Federation Internationale de Volleyball; IAAF, International Association of Athletics Federations; IOC, International Olympic Committee; PCR, polymerase chain reaction

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athletes and sports participation and performance, the author contacted and requested background information from selected members of the IOC Medical Subcommission who studied the issue before making their recommendation to the IOC Medical Commission.

RESULTS AND DISCUSSION

Gender verification

The initial accounts of men masquerading as women in order to compete for the laurels of victory date back to the early cold war period, an era when athletic achievement became a source of both personal and national pride, prestige, and reward. Although much of the available "evidence" is anecdotal and circumstantial, there is reason to suspect that such sex fraud may have been systematically perpetuated for political gain dating back to the 1936 Berlin Olympics.⁷ With opportunities for women to compete in the international sporting arena becoming more numerous, the International Association of Athletics Federations (IAAF) intervened in order to protect track and field from the reoccurrence of similar transgressions by requiring that the female participants in the 1966 European Track and Field Championships parade naked before a panel of female doctors in order to confirm their "femininity." Although all 243 athletes who submitted to this private humiliation passed, six athletes from a single Eastern bloc delegation suddenly withdrew from the competition, precipitating considerable speculation and rumour mongering.^{8,9} Over the succeeding two years, verification of gender became a part of the pre-competition protocol for female track and field athletes, and in 1968 the IOC followed suit by requiring that all female athletes produce proof of their gender in order to be permitted to participate in the Mexico City Summer Olympic Games.^{8,10} Although the accepted methodology of sex testing would evolve over time, in one form or another such gender verification was performed before every subsequent Olympics, until the IOC finally suspended the practice before the Sydney Summer Games.^{7,11}

As described, the initial methods used to verify the gender of female athletes involved physical inspection of the athlete's external genitalia. To spare athletes such embarrassment, from the outset Olympic officials relied on the technology of medical genetics for an alternative, less invasive solution. After successful trialling of the protocol at the 1968 Winter Olympics held in Grenoble, France, all female athletes participating in the Mexico City Summer Games later that year were tested by histological (microscopic) inspection for the presence of a Barr body in cells scraped from the buccal (cheek) mucosa. Although such laboratory based testing held certain advantages, there were also acknowledged limitations to the methodology.¹²

Beginning with the 1992 Albertville Winter Olympics, in an effort to further improve on the sensitivity and specificity of testing, gender verification was performed by polymerase chain reaction (PCR) determination of the absence or presence of DNA sequences from the testes-determining gene located on the Y chromosome. Although the PCR technique was supposed to identify uniquely male DNA sequences, further investigation revealed that at least one of the DNA sequences used to prime the PCR was in fact not specific to males, and may have contributed to an unfortunate number of false positive test results.^{13,14}

Over time, it therefore became evident that laboratory based methods of determining an athlete's sex were simply inadequate for the task at hand. The attempt to rely on genetic testing methods of sex determination had opened up a veritable Pandora's box of problems for both athletes and officials. Not infrequently, the genetic based testing identified an athlete whose phenotype was clearly female as having an

apparently male genotype. The most common of these "intersex states" is the condition of androgen insensitivity,¹² affecting about 1 in 60 000 males. Individuals with this condition have a 46XY genotype (the typical male chromosomal make up), but fail to develop male sex characteristics because their cells cannot respond to the circulating male hormone (testosterone) in their bodies. Although the presence of the Y chromosome makes these individuals genetically male, they are phenotypically female—that is, they have a female morphotype and physiology—and they are usually raised socially as females. The presence of the Y chromosome (and more importantly, circulating testosterone) confers no physical advantage on them.¹² Seven of the eight athletes with non-negative gender verification tests (performed by PCR) during the 1996 Atlanta Summer Olympic Games were determined to have the condition of androgen insensitivity and were ultimately permitted to compete in the Games. The eighth athlete was confirmed to have a less common intersex condition and was also allowed to compete.¹⁵

The accepted laboratory based scientific methodology of verifying an athlete's sex during the period leading up to the Sydney Olympic Games therefore relatively frequently, but unfairly, singled out female athletes whose genetic make up (although not "normal") did not provide them with an undue competitive advantage. Moreover, genetic testing alone also commonly failed to identify female athletes whose physiology would in fact give them a competitive advantage—for example, individuals with virilising forms of congenital adrenal hyperplasia. Further complicating matters, it had become painfully obvious that genetic based testing also failed to account for the psychosocial components of gender. Numerous athletes suffered tremendous psychological harm from the public scrutiny that ensued following the public disclosure of abnormal test results.^{3,16} For these reasons, the scientific and sports medicine communities ultimately stood unanimous in their public opposition to the practice of genetic based gender verification testing.^{10,17-19}

By 2000, 29 of the 34 international sports federations had abandoned routine gender verification testing.³ In some instances sports federations devised alternative strategies to solve the perceived problem of potential sex fraud. For example, in the early 1990s the IAAF replaced genetic based testing with a mandatory, comprehensive health assessment for male and female athletes alike.²⁰ Interestingly, the FIVB was one of the five international sports federations that had yet to rescind their requirement for gender verification before the Sydney Games. (The FIVB has since abandoned routine genetic sex testing, although it reserves the right to require formal testing in cases of extreme suspicion.) Eventually the IOC concurred with the prevailing opinion, and before the 2000 Summer Games decided to indefinitely suspend gender verification testing. In the two Summer Olympic Games and the one Winter Games that have transpired since that decision, there have been no published reports of attempted gender misrepresentation and, given the media and public attention lavished on Olympic athletes in this day and age, it seems highly unlikely to occur in the future. Ironically, one additional deterrent to widespread (or even attempted) gender misrepresentation is the requirement that the athlete's urethral meatus be visualised upon submission of a urine sample for doping control. Although clearly not meant to substitute for the crude femininity testing used decades ago, in practical terms it almost assuredly serves a similar, if unintended, role in that regard.

Transsexual athletes

While there now appears to be general agreement within the international sports community that there is no real need to

perform routine testing to verify an individual's sex, the issue of how best to integrate athletes who have undergone sex reassignment surgery into sex specific sports competition continues to be vigorously debated. The issues involved are far from straightforward,²¹ and ultimately force us to re-examine our definition and understanding of what it means to be a female.

Consider, for example, the following scenario: a transgender male to female athlete—that is, a male who has undergone surgical and hormonal gender reassignment to become a female—dominates a volleyball match to such an extent that other competitors believe it to be unfair that she has been permitted to compete. The athlete subsequently produces the appropriate documents indicating that she is indeed, legally, a female (and not simply a cross dresser or transvestite). The question therefore arises, is it advisable or fair to permit transsexual athletes to compete in sport? Furthermore, should a sports governing body, in the name of fair play, restrict the right of transsexual athletes to participate in the gender category by which society and the law accepts them as human beings?

In regard to the illustrative scenario (which was based on actual events), the FIVB rule is quite clear, stipulating that all international athletes must compete in the category of their birth sex. However, the IOC decided before the 2004 Athens Summer Games that athletes who had undergone sex reassignment surgery would be permitted to compete in all future Olympic Games, provided that they met certain criteria on duration of hormonal treatment or timing of surgery (table 1). Although no transsexual athletes were publicly acknowledged to have participated in the Athens Games, the debate continues as to who is right: sports federations, such as the FIVB, that restrict participation of transsexual athletes, or the IOC, which has adopted the more liberal policy allowing these athletes to compete.

To better appreciate certain nuances inherent in this debate, it is instructive to understand some relevant background information on the condition of gender dysphoria, the underlying diagnosis that compels individuals of one gender to assume the identity of the opposite sex. According to Levy *et al*,²² gender dysphoria is an incurable condition that is “amenable to hormonal and surgical palliation.” It is estimated that as many as 1 in 11 900 males and 1 in 30 400 females have this condition,²³ for which standards of care have been promulgated by the Harry Benjamin International Gender Dysphoria Association, Inc in order to maximise the overall psychological wellbeing and self fulfilment of the transgender individual.²⁴ Definitions of what actually constitutes transsexualism vary, and may be sufficiently broad to encompass an individual who merely “identifies” him/herself or “lives” as a member of the opposite sex. To remain consistent with the definition of transsexualism adopted by the IOC, this review will consider a transsexual athlete to be an individual who has both undergone surgical intervention to alter their phenotype—that is, has submitted to gender reassignment surgery—and is being treated with sex hormones in an effort to adopt the physiology of the opposite sex.

From a physiological standpoint, the critical intervention in effecting the switch from female to male or male to female is hormone treatment, for which a recent review concludes, “there are very few well validated efficacy data for different treatment regimens.”²³ Androgen suppression combined with oestrogen supplementation constitutes the cornerstone of feminisation for male to female transsexuals. The relatively unopposed action of oestrogen contributes to the development of female secondary sexual characteristics (including breast development) that society recognises as culturally “feminine.” Oestrogen supplementation also affects the concentrations of other circulating hormones, including growth hormone. Such therapy is not without risk, however, as treatment with oestrogen can result in potentially unfavourable and dangerous side effects, including venous thromboembolic phenomena, heart disease, and stroke.

What effect does transsexual hormonal treatment have on athletic performance? The performance enhancing effects of testosterone supplementation have been well documented, but our understanding of how androgen deprivation and oestrogen supplementation affect performance is less well understood. Such cross sexual treatment has been shown by Elbers *et al*²⁵ to increase both subcutaneous and visceral fat deposits in male to female transsexuals. In this study, the 20 male to female participants assumed a more feminine pattern of adiposity. Importantly, the authors also document a decrease in radiographically measured thigh muscle cross sectional area among male to female transsexuals. In a recently published follow up study, Gooren and Bunck²⁶ confirmed the enduring physiological effects of androgen deprivation and oestrogen supplementation on muscle bulk in that cohort. After one year of cross sexual treatment, the cross sectional thigh muscle area of the male to female transsexuals declined significantly, such that the mean muscle area approached that of the comparison group (pretreatment measurements from 17 female to male transsexuals). It should be noted, however, that even after one year of treatment, the male to female mean muscle area remained significantly greater than that observed in the female to male comparison group. Furthermore, measurements obtained at three years were not appreciably different from those at one year.

Although it is well appreciated that the skeletal muscle cross sectional area is proportional to contractile force production, it cannot be definitively concluded on the basis of this principally anatomical study that the residual difference between the hormonally treated male to female and the pretreatment female to male group would offer a significant performance advantage to the male to female cohort. In fact, there are no published, peer reviewed studies on the performance related sequelae of the commonly prescribed feminising hormone treatment regimens. A summary document accessed on the world wide web²⁷ suggests that such testing has been conducted on at least one male to female transgender athlete and found that she fell “well within the normal range of female performance characteristics.” More definitive studies need to be carried out in the future, but for now all that can be safely concluded

Table 1 Criteria to be satisfied by transsexual athletes wishing to compete in the Olympic Games in the category of their postsurgical sex

Birth sex	Postsurgical sex	Timing of surgery	Duration of hormonal therapy
Male	Female	Prepubertal	Ongoing
Female	Male	Prepubertal	Ongoing
Male	Female	Postpubertal	2 years (minimum)
Female	Male	Postpubertal	2 years (minimum)

on the basis of the available data is that oestrogen supplementation appears to produce the desired changes in physical appearance, and also results in quantifiable changes in potentially meaningful anatomical variables over time in these individuals.

The decision to categorically restrict male to female transsexual athletes from competing in a given sport as females rests on two critical assumptions. The first is that most people exposed to testosterone from puberty onward will develop physical and/or physiological attributes that contribute to a distinct performance advantage over most women. Although the performance boundaries between male and female athletes have narrowed in the past several decades, there are distinct gender differences that exist on average.⁴⁻⁶ The second assumption needed to justify restricting male to female transsexual participation in female events is that these attributes can withstand the hormonal manipulation of sex reassignment, thereby giving the male to female transsexual athlete an unfair competitive advantage. Certainly, there are some effects of testosterone that cannot be reversed, including (most notably) its effect on postpubertal height in men. Men are on average taller than women, with the pubertal growth spurt accounting for most of the gender difference. This gender discrepancy in height might itself be construed as offering an unfair performance advantage to male to female transsexual athletes who participate in sports for which height is thought to be an asset, such as volleyball, basketball, and netball.

Consequently, selected international sports associations have chosen to distinguish between male to female transsexual athletes who have undergone sex reassignment before puberty and those who have undergone reassignment after puberty.²⁷ For example, both the IAAF and the IOC have opined that males who undergo gender reassignment before the onset of puberty should be regarded as female (table 1). According to the IOC Stockholm consensus,²⁸ surgery must include gonadectomy and revision of the external genitalia, and hormonal therapy must be administered in a verifiable manner. In many ways this situation is comparable to a genetic intersex state, in that the individual would have the chromosomal make up of a male and yet have the appearance and physiology of a female. It would therefore seem reasonable to permit these male to female transsexuals to compete as females. However, for athletes who undergo reassignment after puberty, there remains the possibility that residual testosterone induced attributes could influence performance capacity, and thus it could be logically argued that the decision to permit participation or not should be made on a sport by sport basis.

Let us therefore return to the example of the male to female transsexual volleyball player and investigate if there is evidence that typically male physical attributes such as height actually predict performance success in volleyball. There are numerous studies in the literature that have described the anthropometric features and performance characteristics of elite volleyball athletes.²⁹⁻³³ Although it is clear that volleyball athletes tend to be taller than athletes from other sports, athletic performance appears to depend less on height than on physiological and even psychological factors.²⁹⁻³² In addition, the FIVB has collected observational data revealing that:

- elite female volleyball players are on average taller than female non-athletes
- Olympic volleyball athletes are generally taller now than they were a generation ago
- the gold medal winning women's team in every Olympic Games since 1968 has (with one exception) not been the tallest team in the tournament

- the final ranking of the men's volleyball teams participating in the medal round of the Athens 2004 Summer Games was inversely related to average team height

Thus, insofar as team success in volleyball is concerned, there would appear to be factors more critical to individual performance and team success than average player height. Whether or not these performance and success related traits are hormonally mediated remains to be determined.

As indicated above, the incidence of gender dysphoria syndrome is low, and consequently the frequency with which transsexual athletes might be expected to have a significant impact on a given sport should be similarly low. Spontaneous genetic mutations that produce distinctly favourable performance advantages may also be assumed to occur quite infrequently. Therefore, it might be instructive to consider how an international sports federation would address the issue of a genetically unique individual who, by virtue of their genotype, develops attributes that permit him or her to excel at that sport. Such genetic variability is inevitable, and certainly could produce an "uber-athlete" who would naturally excel at sport. Indeed, it could be argued that elite sport selects for physiological outliers whose genetic potential for excellence has been realised through fortuitous interaction with environmental and cultural factors. Interestingly, there is a well known example of an athlete with a relatively rare genetic condition who excelled at volleyball. The late Flo Hyman was a member of the United States Women's national volleyball team that won a silver medal at the 1984 Los Angeles Summer Olympics. Unfortunately, only after her untimely death was it appreciated that she had Marfan's syndrome. Ironically, some of the somatic traits characteristic of Marfan's (tall stature, long arms) almost assuredly contributed (to some extent) to her success as a volleyball player. The important point is that, although she was clearly phenotypically different from the vast majority of her fellow athletes, Ms Hyman was never (to my knowledge) restricted from competing because she was different, and consequently her considerable talent allowed her to develop into one of the sport's all time greats. Now, as then, there is no article in the FIVB Medical Regulations that would preclude the participation of a similar individual with a unique genetic endowment that resulted in a talent for volleyball.

What rules, indeed what ethic, should govern the ability of transsexual athletes to participate in competitive sport? Can we say with certainty that male to female transsexual athletes have an unfair performance advantage over all athletes who have a 46XX genotype? Does it matter whether male to female sex reassignment occurs before or after puberty? Is the limited evidence that cross sexual hormonal therapy produces significant alteration in physiological variables that are thought to be relevant to athletic performance sufficient to give us confidence that transsexual athletes do not have a compelling (and unfair) competitive advantage? And what of intent? Unlike the male athletes who posed as females decades ago, and most assuredly distinct from those who have defiled sport by intentionally doping, transsexuals do not appear to be motivated by personal athletic gain. Clearly it is not the transsexual athlete's fault that they suffer from the syndrome of gender dysphoria. From what is understood of the condition, the individual who ultimately undergoes postpubertal gender reassignment is not seeking to capitalise on any retained physical advantage in the sporting arena. Levy *et al*²² contend that "the persistent cross-gender identification that results [from gender dysphoria] transcends a desire for any cultural advantages of being the other sex."

Finally, the attentive reader will note that this brief review of gender identity issues in sport has focused exclusively on

situations in which males (or former males) may potentially upset the level playing field of female competition. This emphasis reflects the practical reality confronting sporting officials charged with creating and protecting competitive balance, as exemplified by the case scenario involving the male to female transsexual volleyball athlete. But what about the female to male transgender athlete? Although Gooren's group document the efficacy of testosterone administration to female to male transsexuals in increasing thigh muscle cross sectional area and in reducing subcutaneous fat deposits,^{25,26} there seems to be little concern that female to male transsexual athletes would pose a significant competitive threat to male athletes in most sports. Are female to male transsexuals therefore being unfairly discriminated against by broadly crafted policies that restrict participation of transgender athletes to the category of their birth sex? As a further irony, note that such policies would permit male to female athletes receiving oestrogen treatment to still compete as males, but hormonally treated female to male athletes would be prevented from competing against females, because the presence of exogenous testosterone would identify them as having "doped," a proverbial "Catch-22" situation.

FINAL COMMENT

Although there appears to be a consensus of opinion within sport medicine and governance that determination of a female athlete's genotype is of limited practical utility in this day and age, the complexity of the issues surrounding the participation of transsexual athletes has prevented consensus from being similarly achieved in this matter. Although the psychosocial arguments in favour of allowing transsexual participation would appear to be relatively uncomplicated, there is in my opinion inadequate physiological performance related data to allow an unambiguous position to emerge. It seems clear, however, that every sports authority or governing body, indeed every athlete, will ultimately need to wrestle with these issues and answer the questions raised above. It is not hyperbole to state that the IOC took a bold step when it decided to permit the participation of transgender athletes in the Olympic Games. Experience will eventually tell us whether they made the correct decision, and whether the modern female athletic playing field will remain level. Until such time when we can reflect on that experience with perfect hindsight, we must make the best decisions we can with the information available. However, whatever is decided, we must not forget that our actions will affect the lives of the athletes involved, both transsexual and not, forever.

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REFERENCES

- 1 **Federation Internationale de Volleyball, Medical regulations**, ed. 2004. http://www.cev.lu/mmp/online/website/main_menu/downloads/file_28430/fivb_med_regulations_-_revised_7.pdf (accessed 23 Mar 2005).
- 2 **Lausanne Declaration on Doping in Sport (adopted by the World Conference on Doping in Sport)**. 1999. www.sportunterricht.de/lksport/Declaration_e.html (accessed 23 Mar 2005).
- 3 **Ritchie I**. Sex tested, gender verified: controlling female sexuality in the age of containment. *Sport History Review* 2003;**34**:80–98.
- 4 **Batterham AM**, Birch KM. Allometry of anaerobic performance: a gender comparison. *Can J Appl Physiol* 1996;**21**:48–62.
- 5 **Thomas JR**, French KE. Gender differences across age in motor performance: a meta-analysis. *Psychol Bull* 1985;**98**:260–82.
- 6 **Shepard RJ**. Exercise and training in women. Part I. Influence of gender on exercise and training responses. *Can J Appl Physiol* 2000;**25**:19–34.
- 7 **Dickinson BD**, Genel M, Robinowitz CB, et al. Gender verification of female Olympic athletes. *Med Sci Sports Exerc* 2002;**34**:1539–42.
- 8 **Simpson JL**, Ljungqvist A, de la Chapelle A, et al. Gender verification in competitive sports. *Sports Med* 1993;**16**:305–15.
- 9 **Introducing the, uh, ladies**. *JAMA* 1966;**198**:1117–18.
- 10 **Doig P**, Lloyd-Smith R, Prior JC, et al. Position statement. Sex testing (gender verification) in Sport. *Canadian Academy of Sports Medicine*, 1997. <http://www.casms-acms.org/PositionStatements/GendereVerifEng.pdf> (accessed 23 Mar 2005).
- 11 **Simpson JL**, Ljungqvist A, Ferguson-Smith MA, et al. Gender verification in the Olympics. *JAMA* 2000;**284**:1568–9.
- 12 **Hipkin LJ**. The XY female in sport: the controversy continues. *Br J Sports Med* 1993;**27**:150–6.
- 13 **Puffer JC**. Gender verification: a concept whose time has come and passed? *Br J Sports Med* 1996;**30**:278.
- 14 **Serrat A**, Garcia de Herrerias A. Gender verification in sports by PCR amplification of SRY and DYZ1 Y chromosome specific sequences: presence of DYZ1 repeat in female athletes. *Br J Sports Med* 1996;**30**:310–12.
- 15 **Elas LJ**, Hayes RP, Muralidharan K. Gender verification at the centennial Olympic games. *J Med Assoc Ga* 1997;**86**:50–4.
- 16 **Carlson A**. When is a woman not a woman? *Women Sport Fitness* 1991;**13**:24–9.
- 17 **de la Chapelle A**. The use and misuse of sex chromatin screening for 'gender identification' of female athletes. *JAMA* 1986;**256**:1920–3.
- 18 **Gender verification of female athletes**. *Lancet* 1987;**28**:1265–6.
- 19 **Fox JS**. Gender verification: what purpose, what price? *Br J Sports Med* 1993;**27**:148–9.
- 20 **Ljungqvist A**, Simpson JL. Medical examination for health of all athletes replacing the need for gender verification in international sports. The International Amateur Athletic Federation Plan. *JAMA* 1992;**267**:850–2.
- 21 **Pilgrim J**, Martin D, Binder W. Far from the finish line: transsexualism and athletic competition. *Fordham Intellectual Property Media & Entertainment Law Journal* 2003;**13**:495–549.
- 22 **Levy A**, Crown A, Reid R. Endocrine intervention for transsexuals. *Clin Endocrinol* 2003;**59**:409–18.
- 23 **Moore E**, Wisniewski A, Dobs A. Endocrine treatment of transsexual people: a review of treatment regimens, outcomes, and adverse effects. *J Clin Endocrinol Metab* 2003;**88**:3467–73.
- 24 **Meyer W III (chairperson)**, Bocking WO, Cohen-Kettenis P, et al. The standards of care for gender identity disorders. 6th version. *The International Journal of Transgenderism*, 2001;**5**. http://www.symposium.com/ijt/soc_2001/index.htm (accessed 24 Mar 2005).
- 25 **Elbers JM**, Asscheman H, Seidell JC, et al. Effects of sex steroid hormones on regional fat depots as assessed by magnetic resonance imaging in transsexuals. *Am J Physiol* 1999;**276**:E317–25.
- 26 **Gooren LJ**, Bunck MC. Transsexuals and competitive sports. *Eur J Endocrinol* 2004;**151**:425–9.
- 27 **Australian Sports Commission**. Transgender in sport. www.ausport.gov.au/fulltext/2001/ascpub/women_transgender.asp (accessed 22 Mar 2005).
- 28 **International Olympic Committee**. IOC approves consensus with regard to athletes who have changed sex. http://www.olympic.org/uk/news/olympic_news/full_story_uk.asp?id=841 (accessed 24 Mar 2005).
- 29 **Fleck SJ**, Case S, Puhl J, et al. Physical and physiological characteristics of elite women volleyball players. *Can J Appl Sport Sci* 1985;**10**:122–6.
- 30 **Gualdi-Russo E**, Zaccagni L. Somatotype, role, and performance in elite volleyball players. *J Sports Med Phys Fitness* 2001;**41**:256–62.
- 31 **Leone M**, Lariviere G, Comtois AS. Discriminant analysis of anthropometric and biomotor variables among elite adolescent female athletes in four sports. *J Sport Sci* 2002;**20**:443–9.
- 32 **Stamm R**, Veldre G, Stamm M, et al. Dependence of young female volleyballers' performance on their body build, physical abilities, and psychophysiological properties. *J Sports Med Phys Fitness* 2003;**43**:291–9.
- 33 **Viitasalo JT**. Anthropometric and physical performance characteristics of male volleyball players. *Can J Appl Sport Sci* 1982;**7**:182–8.