



Perspective

The Moral Limits of Enhancement Technologies in Elite Sport

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ABSTRACT

Elite sport's anti-doping regime rests on three overlapping justifications -- fairness, a therapy/enhancement distinction, and health paternalism -- none of which, on close inspection, is as stable as official rulebooks imply.

This perspective examines the fairness argument against enhancement and shows why it survives only in a narrower, enforceability-focused form once genetic luck is taken seriously as an unearned advantage of its own.

It then traces how the therapy/enhancement line, never designed for bodies already trained and selected for biological extremity, is increasingly treated in the literature as an administrative convenience rather than a principled boundary.

Two live regulatory flashpoints are examined in detail: gene doping, where the ethical verdict against the practice arrived well before any reliable means of detecting it, and sex-based eligibility rules for women's competition, where policy has arguably moved faster than the underlying evidence.

We argue that a defensible position going forward must treat these cases separately rather than as instances of a single 'enhancement' problem, prohibiting what is genuinely unsafe and coercive while being transparent about how much of current doctrine rests on contestable line-drawing rather than settled bioethical consensus.

Keywords: human enhancement; sports ethics; gene doping; anti-doping policy; athlete autonomy

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INTRODUCTION

Elite sport has always tolerated a certain amount of biological unfairness -- some athletes are simply born with better lungs, longer limbs, or more favorable

muscle fiber ratios than their competitors. What it has not tolerated, at least officially, is athletes purchasing those same advantages through medicine. That distinction has grown harder to defend as the tools

available to athletes have moved from blood transfusions and anabolic steroids to gene transfer techniques, CRISPR-adjacent editing, and increasingly precise pharmacological manipulation of recovery and endurance [1]. Sport governing bodies have responded with an ever-expanding prohibited list, but the philosophical case for where that list should stop has never been settled, only administered [2].

The debate is no longer purely theoretical. A privately organized competition branding itself the "Enhanced Games" has proposed staging elite athletic events with no anti-doping testing at all, on the argument that current prohibition regimes protect an incoherent ideal of "natural" performance while doing little to actually protect athlete health [3]. Whatever one thinks of that project, it has forced bioethicists to state more precisely what they think doping prohibition is actually for -- fairness, health protection, the integrity of some notion of sport itself, or some combination that trades badly against the others [4]. This review works through that question by tracing four things recent literature has sharpened: the fairness argument against enhancement, the therapy/enhancement distinction that anti-doping rules quietly depend on, the health-paternalism case for prohibition, and two live case studies -- gene doping and the regulation of transgender and differences-of-sex-development athletes -- where the abstract debate has concrete regulatory stakes.

THE FAIRNESS ARGUMENT AND ITS LIMITS

The most intuitive objection to performance enhancement is that it is unfair: an athlete who dopes gains an advantage that competitors following the rules cannot match without doing the same. But this argument proves less than it initially appears to. Elite sport already permits, and in some cases celebrates, enormous unearned biological advantages -- altitude-adapted lung capacity, genetically favorable tendon elasticity, growth-hormone variation -- that athletes did nothing to deserve and cannot be asked to level [5]. If the objection to doping is that it creates an advantage the athlete did not earn, that objection proves too much, since it would equally condemn genetic luck. Some philosophers have pushed this further and argued that if the underlying concern is really about unearned advantage, a rule permitting supervised enhancement for everyone who wants it would be fairer than one that bans it selectively while doing little to actually catch violators [6].

The fairness argument survives in a narrower form once it is reframed around enforceability rather than pure desert: a rule against exogenous enhancement is fair not because it levels all biological variation but because it is at least a rule everyone is nominally bound by, whereas a permissive regime would predictably reward whichever athletes have the best access to expensive, medically supervised

enhancement protocols, reintroducing inequality along economic rather than genetic lines [7]. This is close to Loland's argument that anti-doping's moral foundation, however imperfectly enforced, rests on a shared and voluntarily accepted rule structure rather than on any deep claim about what counts as a "natural" body [2].

THERAPY, ENHANCEMENT, AND THE LINE THAT WILL NOT HOLD STILL

Much of sport's anti-doping architecture depends on a therapy/enhancement distinction that was never built to bear this much weight: therapeutic use of a substance to restore an athlete to normal function is permitted (often through a therapeutic use exemption), while the same substance used to push function above the population baseline is prohibited. The trouble is that "normal function" is not a fixed biological fact for an elite athlete, whose baseline is already several standard deviations from the population mean on the traits that matter for performance [8]. A hematocrit level that would be pathologically high in an untrained adult may simply describe a well-adapted endurance athlete's resting state, which makes any bright line between restoring and enhancing partly arbitrary once applied to bodies already selected and trained for extremity [9].

Philosophical treatments of this problem generally conclude that the therapy/enhancement line was always a policy convenience rather than a metaphysical discovery, useful for triaging medical resources but poorly suited to settling questions about competitive fairness [10]. McKeown's extended treatment of the distinction argues that it survives in bioethics mainly because alternatives are administratively harder to apply, not because it tracks a coherent moral difference between the two categories [11]. Applied specifically to sport, Miah's account of the "transhuman athlete" argues that competitive sport has never actually rewarded untouched nature so much as the most effective legal optimization of a body within whatever rules currently apply, which is itself a moving target as training science and medicine advance [12]. Table 1 summarizes how the main rationales offered for restricting enhancement diverge once the therapy/enhancement line is treated as unstable rather than fixed.

HEALTH, PATERNALISM, AND THE CASE FOR PROHIBITION

A second and arguably sturdier justification for restricting enhancement rests not on fairness but on athlete health: gene transfer techniques, in particular, involve real and poorly characterized risks, including insertional mutagenesis, uncontrolled overexpression, and immune responses to vector delivery, none of which have been through anything resembling the safety evaluation required of an approved therapeutic [13]. On this view, prohibition is a paternalistic but

defensible response to a genuine coercive dynamic in professional sport: if enhancement becomes available to any competitor, all competitors are effectively forced to use it or accept a competitive disadvantage, which converts what looks like an individual choice into something closer to compulsion [14].

Table 1. Rationales commonly offered for restricting enhancement in elite sport, and the main objection each faces once the therapy/enhancement line is treated as unstable.

Rationale	Core claim	Main objection
Fairness (unearned advantage)	Enhancement grants an advantage the athlete did not earn	Proves too much: genetic luck is also an unearned, uneven advantage that sport already tolerates
Therapy/enhancement line	Restoring function is permitted; exceeding a normal baseline is not	"Normal" is not fixed for elite athletes already several standard deviations from population baselines
Health paternalism	Prohibition protects athletes from coercive pressure to accept unsafe interventions	Critics argue prohibition drives use underground into less-supervised, more dangerous settings
Integrity of sport	Enhancement erodes what counts as the athlete's own achievement	Elite training already optimizes the body technologically; the line between training and enhancement is contested

Proponents of harm reduction have pushed back directly on this reasoning as applied to existing pharmacological doping (as opposed to speculative gene editing), arguing that current prohibition drives use underground into unsupervised, unmonitored settings that are considerably more dangerous than medically supervised enhancement would be, and that a harm-reduction framework -- physician oversight, mandatory monitoring, capped substances -- would protect athletes better than a blanket ban enforced by intermittent testing [15]. A recent set of commentaries organized around the Enhanced Games concept takes this argument seriously enough to propose it as an actual research and policy program rather than a rhetorical provocation, framing the current anti-doping regime as a prohibition-era experiment whose costs -- underground use, stigma, uneven enforcement across wealthy and poor sporting federations -- have been undercounted relative to its benefits [16]. Critics of that framing counter that removing prohibition does not remove the coercive dynamic Murray describes; it simply relocates the coercion from "dope or lose" to "dope under supervision or lose," and that athlete autonomy in a winner-take-most labor market is not obviously protected by legalizing the practices that market pressure already selects for [17]. Others note

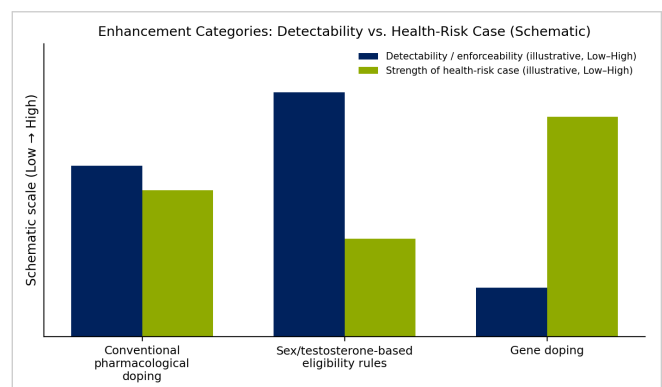
that "harm reduction" language borrowed from drug policy assumes a baseline of ongoing, hard-to-eliminate use, which may not transfer cleanly to a domain where the enhancement in question is being introduced specifically to gain competitive advantage rather than to manage dependence [18].

GENE DOPING: A CASE WHERE DETECTION LAGS ETHICS

Gene doping occupies an unusual place in this debate because the practical problem -- detection -- has consistently outpaced the ethical one. Anti-doping authorities have had a stated policy against gene doping since before any confirmed case existed, largely because the techniques were, and mostly remain, difficult to distinguish from an athlete's own genetic variation once a transgene has integrated and begun expressing a natural protein at elevated levels [1]. This creates a strange asymmetry: the ethical case against gene doping was made and largely settled -- unacceptable risk, coercive pressure on competitors, erosion of what counts as the athlete's own achievement -- well before there was any reliable way to enforce the resulting rule [13]. Figure 1 offers a schematic comparison of how three prohibited or contested enhancement categories score on two axes recurring throughout this literature: detectability and the strength of the health-risk case against them, illustrating why gene doping in particular sits in the hardest quadrant for regulators -- ethically clear-cut but operationally almost invisible.

Recent bioethics commentary has also connected the gene doping debate to broader unease about sport's soft-power function: elite competition is increasingly treated by states and sponsors as a vehicle for national and commercial prestige, which creates institutional incentives to under-enforce enhancement rules quietly while maintaining strict rules on paper, a dynamic that undermines the fairness rationale for prohibition regardless of how sound that rationale is in the abstract [19].

Figure 1. Schematic comparison of three enhancement-adjacent categories on detectability/enforceability and strength of the health-risk case against them (illustrative scale, not derived from a single empirical study).



THE SEX-BASED ELIGIBILITY DEBATE AS AN ENHANCEMENT-ADJACENT PROBLEM

A structurally similar debate, though not usually framed in enhancement terms, concerns eligibility rules for transgender women and athletes with differences of sex development in women's competition categories. World Athletics and other federations have adopted testosterone-based eligibility thresholds on the theory that endogenous testosterone confers a performance advantage large enough to threaten the integrity of women's competition, a rationale that echoes the enhancement debate's core fairness question but applies it to an athlete's own physiology rather than to something exogenously administered [20]. Critics argue the evidence base for a sharp testosterone threshold is thinner than the policies suggest, and that the rules function less as an evidence-driven fairness measure than as a proxy for policing who counts as a legitimate female competitor at all [21].

A comprehensive recent review of this literature found that policy in this area has moved considerably faster than the underlying sports-science evidence, with governing bodies frequently citing performance-advantage claims that the cited studies do not straightforwardly support, and recommended more transparent, iteratively revisited eligibility criteria rather than fixed thresholds treated as settled science [22]. Others have argued the debate cannot be resolved by evidence alone because it ultimately turns on a contested question -- what a sex-segregated competitive category is actually meant to protect -- that sports science is not equipped to answer on its own [23]. The parallel to the broader enhancement debate is not incidental: in both cases, regulators are drawing lines around which forms of biological advantage are legitimately "one's own" and which are not, using criteria that turn out to be considerably more contestable than the confident language of official rulebooks implies [24].

CONCLUSION

None of the standard justifications for restricting enhancement in elite sport -- fairness, the therapy/enhancement distinction, or health paternalism -- survives close examination fully intact, yet none of them collapses either. Fairness arguments prove too much once genetic luck is taken seriously, but survive in a narrower, enforceability-focused form. The therapy/enhancement line is administratively convenient rather than metaphysically sound, but abandoning it entirely would leave anti-doping systems with no principled starting point at all. And the paternalist case for prohibition has real force against high-risk interventions like gene transfer, even as harm-reduction critics make a serious case that current enforcement patterns may cause more harm than a more honest, medically supervised alternative would. What the recent literature adds is less a resolution than a clearer map of where the genuinely hard cases sit:

gene doping, where the ethical verdict is closer to settled than the detection technology; and sex-based eligibility rules, where the ethical debate is arguably less settled than the confidence of current policy suggests. A defensible position for sport governance going forward likely needs to hold these apart rather than treating "enhancement" as a single category with a single answer -- prohibiting what is genuinely unsafe and coercive while being honest about how much of the rest rests on contestable line-drawing rather than settled bioethical consensus.

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Conflict of Interest

The authors declare no conflicts of interest relevant to this work.

Author Contributions

Wolfgang de Boer conceived the review, developed the overall argument, and drafted the sections on the fairness argument and the therapy/enhancement distinction. Dimitris Havlicek conducted the literature synthesis on health paternalism, harm reduction, and gene doping, and critically revised the manuscript. Giulia Saez-Bermudez contributed the section on sex-based eligibility rules, prepared the table and figure, and coordinated the final revisions. All authors read and approved the final manuscript.

Ethics Statement

As a literature review synthesizing previously published, publicly available research and policy analysis, this article did not involve new data collection from human participants and did not require institutional ethics committee approval.

Data Availability

No new data were generated or analyzed for this review. All sources discussed are cited in the reference list and are publicly available through their respective publishers.

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