Bioethical Concerns in an Era of Human Enhancement

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Citation:
Miah, A. (2011) Bioethical Concerns in a Culture of Human Enhancement. In Bouchard, C. & Hoffman, E. Encyclopedia of Sports Medicine, Genetic and Molecular Aspects of Sport Performance. Lausanne, International Olympic Committee, 383-392.

Identifying the moment when genetic science became an ethical concern for the world of sport is difficult. When Watson and Crick first characterized DNA in 1953, with the assistance of Rosalind Franklin (Hubbard, 2003), this initiated a whole series of discoveries and questions about the future of humanity, the implications of which are only beginning to become manifest within social practices, such as sports. Yet, genetics in sport certainly gained special attention around the publication of the initial sequence of the human genome in 2001. At this time, athleticism was one of many characteristics that the popular science press represented as being genetically determined, via headlines about "performance genes" (Coghlan 1999). Yet, many of the scientific studies on which such claims were based were far more modest in what they claimed the findings revealed. Nevertheless, this period gave rise to numerous debates about how genetic science would have a major impact on sport. Moreover, public concern over the direction of science, required institutions to take into account the ways in which science may be applied to the detriment of individuals or society more generally. This anxiety extended to the world of sport, either directly via the IOC or the World Anti-Doping Agency, or indirectly through agencies that dealt with the ethics of emerging technology, many of which identified sport as a likely area of application.

Since the early 2000s, debates about the ethics of genetics in sport have been dominated by the prospect of gene doping, the use of gene transfer technology for non-therapeutic or enhancing purposes. This technology promises a new era of performance enhancement in sport, which may call into question the possibility of detecting and catching users. Despite this possibility, the World Anti-Doping Agency (WADA) began to investigate the prospect in 2001 and responded in 2003 by prohibiting "gene" or "cell" doping within the 2004 World Anti-Doping Code (see WADA, 2003) which read: M3. Gene Doping. Gene or cell doping is defined as the non-therapeutic use of genes, genetic elements and/or cells that have the capacity to enhance athletic performance' (p.14).

Additionally, WADA's funding of scientific research into establishing indirect testing methods for gene doping places the anti-doping authorities in a unique position, in which they may be ahead of the users. In particular, by establishing lines of cooperation between the world of sport and the developing biotechnology industries, whose products might be used by athletes, there is an opportunity to affect the use of gene doping before it is readily available.

In this context, the present chapter provides an overview of the ethical and policy issues that surround the development and use of genetic and molecular science in sport. It begins by exploring the characteristics of sports and identifying why ethical concerns about technology generally and genetics specifically should be of special concern to sports medicine. It then considers the main purposes to which genetic science may be put within sport – specifically, research, genetic information and gene transfer – in order to outline the ethical and policy considerations that they provoke.

An integral part of this analysis involves taking into account the vast range of cultural values that surround sports practice and genetic research, which differ remarkably throughout the world. Arguably, what distinguishes the ethics of genetic science in sport from other forms of scientific application is the way that it interfaces with a range of fundamental moral concern about the sanctity of life, human dignity and what it means to be human (Miah, 2004). When developing policy guidelines on the use of genetic science, sport's challenge is to take into account these complex philosophical concepts where diverse cultural differences also exist.

Universal rules and particular cultures

A distinguishing feature of sports is their reliance on universally accepted rules, which permit a reasonable, meritocratic basis on which to evaluate and compare performances. For example, in sprinting, athletes – via their Federation – agree on the means by which they will run, the distance they will cover, when they will start and so on.[i] One can distinguish between various types of such rules: constitutive, regulative and auxiliary. Thus, the constitutive rules "stipulate a goal and the means...by which this goal can be attained" (Loland 2002), while regulative rules are "logically independent of the process of competing", and include such dimensions as fixing the "appearance, size, and weight of the golf ball". Auxiliary rules are extraneous to the competitive situation, but nevertheless govern what takes place. As Loland describes, this includes such rules as separating male and female into different competitions.

These rules describe the formal mechanisms through which sports promote fairness of competition. Additionally, there are tacit, unwritten rules that shape the ethical environment of sports, or its *ethos*. For example, often in soccer an attacking team will deliberately put the ball out to the touchline, if a member of the opponent's team has become injured. Subsequently, despite the rules indicating that the opponents will then have the advantage – which they may rightfully use to attack – it is commonplace that they will voluntarily return the advantage to their opponents as a reciprocal courtesy. Sports are full of such examples of ethically praiseworthy behavior, indicating that what the rules indicate formally does not encompass the richness of moral action that exists in competition. Arguably, it is through such gestures where the strongest examples of fair play take place within sports, thus challenging the idea that elite sports results are won at all costs. Moreover, there is often consensus over the acceptance of such rules, in order to preserve the possibility of meaningful competition.

When expanding our range of ethical concern to the training field, rather than just competition, the ethos is much more ambiguous. Moreover, the way that science is used to affect sporting potential is a clear exemplar of this ambiguity. In part, this is because sports have changed over time from being practices largely constituted by technology, but only rarely modified by it, to practices that are wholly immersed within a scientific culture. Thus, today, the development of technology and technique is an integral part of what we understand as sports performance, and this shift coincides with how the value system of sports has changed over time. As Guttmann (1978) puts it, sports have shifted "from ritual to record" and consequently, have become practices that are especially interested in quantification and measurement, rather than ceremony and ritual. The breadth of this technologization is considerable and includes modifications in technique, transformations to equipment, the use of sophisticated biomonitoring devices, and greater knowledge about biological systems. Such knowledge informs a number of behavioral patterns that alter athletic performance, such as hydration, nutrition, rest and so on.

While it is easy to embrace such changes when they are clearly therapeutic, unease about these transformations is evident in the concomitant concern that technologization may lead to the dehumanization and mechanization of athletic performance (Hoberman, 1992).[ii] While the immediate historical context of this is the 1980s, when East Germany undertook programs to enhance their athletes via illegal doping methods, there are broader sociological roots that inform such perspectives. Specifically, heightened concern about automation within modern society as a deeply alienating process leads some to conclude that society may be, overall, worse off from such changes.

The mechanization thesis is made even more complex – technically and ethically – in an era of genetics and molecular science. The prospect of selecting or engineering humans creates frightening images often portrayed through totalitarian societies, where humanity collapses under the hyper-scientization of society or misguided attempts to build a better human race, which has appeared more than once in human history. As well, cultural texts

have often served as a warning about the prospect of a technologically dependent future. The kind of surveillance described in Huxley's *Brave New World* and movies such as *GATTACA* or *Bladerunner* offer an imagined future where technology undermines what is valuable about being human, often to its destruction. Thus, the science of molecular mechanization implies a more invasive form of transformation, even if the actual complexity of the procedure is nothing more than an injection with a needle. This is because there are both cultural and moral distinctions between, say, adapting the body via an exercise machine such as a treadmill and transforming the genetic composition of an athlete. The relevant differences may not reside in the actual affect upon performance; both may allow an athlete to run longer. For example, consider the recurrent discussions about swimming costumes that purport to provide a performance advantage. Such technology might similarly improve performance, as might a biological enhancement. Yet, the critical moral concerns involve such issues as reversibility or the capacity to affect subsequent generations. Such matters concern sports federations for a number of reasons, but principally because the use of such technology is often associated with affecting the merit of an athlete's performance. Thus, attempts at enhancement may affect the conditions of competition in such a way as to invalidate the kind of praise and admiration we have for the athlete's achievement.

To this end, ethical considerations of genetics and molecular science in sport are fundamentally concerns about justice in sport. However, they also imply broader questions about social justice, since the conversation is often about access to sophisticated medical technology, the privatization of which could contradict broader societal aspiration to distribute primary goods evenly. Yet, there are also important moral considerations that arise from *withholding* the use of science and technology. Thus, while their use might disturb equality within sport, withholding their use may also preserve existing inequalities. Recall that sports try to promote equality, not maintain it. For example, one might claim that some people have a genetic constitution that is more suited than others for particular kinds of sport. A simple exemplar of this is the genetic predisposition towards height, which can be helpful for a number of sports. Thus, were it possible to genetically alter the eventual height of an individual, one might claim that this is reasonable on the grounds that failing to do so permits an unfair inequality to exist among an athlete population. This pro-enhancement perspective has gained prominence over the last ten years and will be revisited later in the chapter.

Bioethics in sport

Since the popularization of genetic science in the 1990s, scientific research in this area has been matched by the expansion of bioethical investigations into the subject. These inquiries include the consideration of such issues as the patenting of human DNA, the use of genetic selection, and the possible use of gene transfer for non-therapeutic applications. In addition to this, genetic and molecular science are part of the converging sciences, which encompass nanotechnological, biotechnological, informational and cognitive sciences, thus making the realm of ethical debate even more contested and subject to various interests and shifting political interests (Roco & Bainbridge 2002). A concomitant research agenda has emerged over this period to evaluate how science reaches the public.[iii] Thus, studies in the *public understanding of science* and evaluations of media narratives on genetic science have become an important feature of the biopolitical landscape.[iv] Prominent controversies surround the publication of research that often rely on small scale populations, though which generate large-scale media coverage. Such reporting often involves dramatic claims about the potential to transform humanity via such research findings. Sport is one area that has been a focal point for such propositions and is generally a practice that is subject to regular discussions about the future of humanity and its ongoing transformation by technology (Miah & Eassom, 2002).

To this extent, the cultural context of genetic and molecular science plays an important role in shaping how sports organizations react to its utilization. For example, consider the story that indicated five British footballers planned to store the stem cells of their children to protect themselves (and their children), should they become injured during competition (Templeton, 2006). In this situation, a number of complex issues arise that reflect the cultural context within which genetic technology has developed. First, the footballers' intentions imply an acceptance of the legitimacy to harvest stem cells, which is not something that is shared in all countries. Second, the fathers presume an entitlement to utilize the cells of their children for their own means, rather than consider that these cells belong only to the child. Third, the possibility of undertaking such a decision exists in a country where the industry of commercial stem cell storage exists, which is a possibility that is not available to all nations.

How should the sports world react to such possibilities? Is it fair that these footballers have access to a technology that could assist them in recovering more effectively and quicker, when others do not? Should the sports world be obliged to promote the utilization of such technology to optimize conditions of equality? Alternatively, does the utilization of such technology constitutive a terrain that is extraneous to what the sports world can embrace as its responsibility? Must it ultimately accept what society considers acceptable, rather than seek to prohibit or control its use? These questions reflect the complexity of the ethical debates both for individual users who may seek more technology to enhance their performance or their resilience and for the sports industries, which attempt to regulate fair competition. They also reinforce the claim that policy development on genetic science in sport cannot exist in isolation from broader social policies on genetics.

However, the challenges presented by genetics are not exceptional. For many years, sports have negotiated such ethical terrain where, at times, it has sought to strictly restrict the use of technology and, on other occasions, has embraced it fully (Miah, 2005). Nevertheless, in subsequent years, this challenge will become even greater, as new applications emerge and as opinions differ on their legitimacy to alter humanity. Moreover, it is not just humans that are affected by this science. For example, controversies have already arisen about the cloning of racehorses (Coghlan, 2005).

To what extent can sports rely on established ethical codes of conduct to address this emerging science? Is it reasonable to expect the direct application of bioethical principles to meet the range of ways that genetic science will be applied to sport? In the mid-1990s, Murray (1997) argued *against* the idea of "genetic exceptionalism", a concept that supports the treatment of genetic science as ethically distinct from other sciences. Instead, Murray explains that there are some new challenges that genetics faces, but that the way we have addressed ethics in science and medicine previously should not be dismissed, as if it is no longer relevant or useful. Yet, cultural theorists Nelkin and Lindee (1995) argue that the symbolic status of the gene does require that we treat it differently, if not ethically, then at least sociologically. They argue that genes have a special status, and this requires us to distinguish them from other units of our biology if only because people hold such beliefs. This need not mean that societies devise new ethical codes to take into account such beliefs, but it might require taking into account special sensitivities that arise because of the importance people give to genes. It might also imply revising ethical protocols, such as the consent process, to account for the different ways in which people make sense of genetic information. Arguably, this is why the importance of genetic counseling has been emphasized in a clinical context, as these sensitivities give rise to new obligations for the world of sport to address.

Understanding how best to approach these questions involves looking back on how ethical theory has changed in a post-genomic era. In the context of medicine and technology, early approaches to bioethics and medical ethics focused on developing principles that could

govern good practice, notably through the work of Beauchamp and Childress (2008), which dominated the rise of bioethics in the post-war period. Their four principles – autonomy, beneficence, non-maleficience, and justice – have shaped the development of ethical codes within modern medicine and science. In recent times, scholars have critiqued this top-down principalism, arguing that the lived reality of ethical conduct is much more complex and that ethical codes must be informed by these circumstances. Thus, a bottom-up approach to deriving ethical guidelines has also emerged, so-called casuistry (the study of cases). Today, a method of *reflective equilibrium* has become commonplace within applied ethical settings, which relies on a combination of the two approaches, while increasingly empirical research is informing the characterization of ethical dilemmas within the medical setting (Haimes 2002). To some extent, the world of sport has yet to fully adopt these methods of ethical reasoning, though some studies do emphasize their importance (Butryn 2003, Butryn & Masucci, 2009).

Categories of ethical concern

The ethical debates surrounding genetics and molecular science in sport can be separated into three distinct territories: research and development, using genetic information, and gene transfer. Each of these areas is closely related in a variety of ways, and the latter two are reliant heavily on the first. This is why many of the struggles fought by genetic scientists have aimed to dampen the claims over controversial, radical applications, such as designer babies, and instead emphasize how research will be instrumental to our treatment of seriously debilitating illnesses. While other chapters in this volume deal with each of these issues in detail, it is useful to identify a range of ethical and policy issues that are common themes within all three and address the ways in which the policy world has attempted to deal with them.

A particular controversy that surrounds the use or development of genetic science in sport is the distinction between research and application. Unfortunately, discourse about the two often blurs together, and the development of science can suffer due to a misunderstanding within the public imagination made manifest through public policy. Indeed, an established complexity of scientific research that might have a bearing on the world of sport is its tendency to develop within a medical context. For example, Lee Sweeney's research on insulin-like growth factor 1 (IGF1) aspires to treat muscle-wasting diseases. Yet, Sweeney's work has also been at the forefront of the gene doping debate – much more than the research might otherwise have been – in part due to his willingness to engage publicly on how the future of his work could be utilized (Sweeney 2004). Sweeney's 2004 publication on IGF-1 was also one of the earliest studies to indicate the potential for sports:

> "However, this work raises a number of ethical considerations about the use of IGF-1 in gene therapy, as its beneficial effects could be used in humans for athletic or cosmetic purposes, rather than for disease treatment" (Barton-Davis et al, 1998).

There are many other genetic scientists whose work holds similar implications and this presents challenges for anti-doping policy makers. This is because the kind of developmental work that goes into medical research is highly protected until commercialization. Yet the capacity of the sports world to address illegal uses of such technology relies on early indications of the products that are likely to emerge on the market, to ensure it can develop robust anti-doping tests. In addition, the controversy surrounding gene doping has meant that experimental research surrounding genetics and exercise science has also met with skepticism within the policy community. As a result, the British Association for Exercise and Sport Science (Wackerhage et al. 2009) recently published a position statement arguing on behalf of genetic research in sport. The authors assert that there are novel challenges presented by genetic science in sport, but that there should be encouragement to continue. For example,

one of the difficulties with separating research from application is the unexpected knowledge that might derive from research, as time goes on. For example, they discuss how

> "..a polymorphism in the gene encoding the human bradykinin receptor B2 was shown to be associated not only with exercise-induced cardiac hypertrophy (Brull, et al., 2001) but later that it also predicted coronary risk (Dhamrait, et al., 2003)." (ibid: 1113).

Outside of sport, the use of genetic information is also taken very seriously. Hendriks (1997) argues that, "the unrestricted use of genetic information poses a number of threats to the exercise and enjoyment of human rights" (p.557). The apparent desire of employers or insurance companies to have access to genetic information, as a tool for limiting economic risk, invites scrutiny due to its potential for discrimination by the Australia Law Reform Commission (ALRC) (2003). Moreover, the possibility of identifying specific genetic characteristics, coupled with the possibility of selecting in or out certain traits, may lead to considerable social pressure to undertake such decisions. Indeed, one might envisage that such choices become an integral part of what is deemed to be responsible practice in sports talent identification.

Again, these circumstances reveal the broad societal concerns that orbit the use of genetic science in sport. Genetic testing in sport has arisen in two prominent cases. The first is outlined by the ALRC (2003), which was the first major investigation into the use of genetic information in sport. Here, they outline the case of the Professional Boxing and Combat Sports Board of Victoria, which discussed whether genetic testing could be used to help physicians advise (or better inform) the athlete about the level of risk in their competition. McCrory (2001) mentions a similar concern, explaining how "delayed cerebral oedema after minor head trauma" has been linked to "an abnormality with the CACNA1A calcium channel subunit gene" (p.142). McCrory argues that these findings are important enough to require physicians to offer advice against participation in sports and even to require athletes to take genetic tests, where such risk exists. Moreover, the ALRC note that a "milder form of this condition can occur in players of rugby, soccer, and other sports associated with repetitive blows to the head" (section 38.29, p.964). Yet, the Boxing Board decided against the use of such tests. A second case was of Ed Curry, basketball player for the Chicago Bulls team, who was required to undertake a genetic test after he had missed games due to an irregular heartbeat. Curry refused the test and transferred to the New York Knicks in 2005, a club that did not require that he take such a test.

The two examples highlight the complexity of maintaining ethical principles – such as confidentiality – in what are often high-profile cases. Moreover, they highlight the legal uncertainty within the sports world over how to address claims from a range of parties over access to genetic information. Alongside these debates, a number of conversations have also taken place about the use of genetic information to make selection decisions on the basis of *athletic potential*, rather than liability of health risk. For some time, there was ambivalence about the legitimacy of such selection decisions when even the IOC President Jacques Rogge reportedly indicated that there is nothing obviously wrong about refining talent identification techniques using genetic information: As Clarey (2001) notes,

> "Though it is too soon for sports legislation, Rogge favors a declaration of principle now: "Yes" to genetic screening, which is the examination of a prospective athlete's genes to see which sport would be the perfect fit (perhaps less than five years away). "No" to genetic manipulation."

However, the lived reality of such testing has led sports leaders to revise their position on such use. In particular, in 2004, the first commercial test for a performance gene reached the market, called the ACTN3 Sports Performance Test™. It claimed to identify whether the

user may be "naturally geared towards sprint/power events or towards endurance sporting ability." (Genetic Technologies Ltd, 2004). Around the same time, *Nature* reported that an Australian rugby league team would experiment with genetic tests to improve their ability to train athletes and direct them towards success within competition (Dennis 2005). Soon after, WADA responded with its *Stockholm Declaration* (2005), which "strongly discouraged" the use of such tests by sports organizations, especially to make selection decisions.[v]

The use of genetic information reinforces the broader societal implications of the genetics issue in sport. Such concerns can involve extending the realm of parental autonomy, though in dramatically different ways. For pre-natal selection decisions, it would involve presenting parents with decisions about what kind of embryo they bring into existence. Alternatively, in a post-natal setting, it can imply using a mouth swab to identify what sports children might excel in. The ethical and moral objections to such technology being used range from a concern about engendering an endless spiral of biotechnological competitiveness to anxieties that such selection decisions exhibit unjustified and inappropriate prejudices towards certain kind of people over others (see Miah 2007). Yet, it may also be argued that these freedoms fall well within the realm of parental liberty and so do not present such great harms as to require prohibition.

A number of practical questions also emerge from such prospects, which have yet to be resolved. For example, would athletes be required to undergo genetic screening to establish their genetic constitution before being allowed to compete in sports? In what ways could sports authorities and their stakeholders have access to the information derived from genetic tests to identify doping practices? How would genetic testing influence an athlete's enjoyment of sport? If an athlete has an unusually favorable phenotype, would this lead to their disqualification from competition?

Where genetic testing is used to identify talent, concerns over discrimination are of a different character. Here, the concern is that the testing method may not be an adequate indicator of performance potential. Indeed, the complexity of sports is such that making absolute judgments about what characteristics will ensure or even increase the probability of success is difficult. For example, one may reasonably argue that extreme shortness (or extreme height) prevents an individual from performing the required skills of many sports. As such, by claiming that height is a relevant characteristic of sporting performance, one may then claim that genetic tests could be used to justify why short children are not selected in an elite training program. Yet, this conclusion is insufficient, since there are many people who may perhaps welcome the chance to become an elite athlete, but for whom there is no opportunity due to the tests. Indeed, such arguments could be made in relation to a number of disabilities, for which it would be unreasonable to claim that such aspirations do not deserve support. Thus, clearly there is a sense in which sport depends on providing opportunities for different kinds of people. Moreover, it seems preferable to adapt the structures in sport to allow the possibility of such people to pursue elite competition, rather than to endorse a system, which excludes certain kinds of people from participating. If this additional commitment requires creating greater divisions within sports, then this should be the responsibility of sports federations, since the value of sport depends on inclusivity.

An additional complication in the context of sport is taking into account the life course, where participation in sport often starts at a very young age. This has a specific bearing upon the use of such testing and selection in children since a child may enjoy many years as a competitive athlete, before reaching a point where genetic factors limit competitiveness at an adult level. Consider a young basketball player who is destined to be 165cm tall, who may enjoy being an excellent player until his peers have undergone their final growth spurts. The value a child may accrue from these experiences is clearly sacrificed, were a genetic test to be used early in life reveal that his eventual height would likely limit competitiveness in

adulthood.

If discussions about genetic information reflect the present-day use of genetic information, conversations about gene transfer in sport are its future. These debates have been dominated by the prospect of *gene doping*, the use of gene transfer for non-therapeutic or enhancing purposes. A range of institutions take this prospect seriously and include WADA, the American Association for the Advancement of Science, the United States President's Council on Bioethics, and the British Government (House of Commons, 2007). A number of philosophical and ethical issues surround the debate on gene transfer in sport. On a philosophical level, there is a need to distinguish between types of therapy and non-therapy (Miah 2008). For example, while the WADA Code accepts the use of gene transfer for therapeutic use, it is unclear whether the distinction between therapy and enhancement can be sustained in the long term. Thus, insofar as genetic disorders are often linked to age-related diseases – such as muscular depletion – it might be medically desirable to "enhance" people in order to maintain a reasonable level of health. Moreover, it might appear that individuals must be treated with gene transfer well before they are symptomatic, that is, when they are considered healthy. These prospects are receiving careful consideration from a range of governments around the world. As noted in the introduction, the United States President's Council on Bioethics (2003) discussed this prospect in the context of sport and identified no clear consensus on what should follow in policy terms. In addition, the British House of Commons (2007) investigation also reinforced the likely expansion of such modifications in society. More recently, the European Parliament committee STOA (Coenen et al. 2009) identified a series of key priorities around human enhancement, which included gene doping.

Ethically, the recurrent questions are about how such technology would affect equality in sport and broader notions of justice. WADA's approach to any new technology is to identify whether it engages two of the three of its criteria: performance enhancing, risky to health, and against the spirit of sport. If two conditions are engaged, then it will *consider* prohibition. While the use of gene transfer remains highly experimental, it may give rise to forms of performance enhancement that are safer than current methods that rely on synthetic substances – often from an illegal black market. On this basis, there might be good reason to promote these healthier modes of human enhancement in order to diminish the illegal trade of substances that currently overshadows elite sports. Moreover, through the utilization of biomarkers and DNA passports, there might be a greater potential to monitor the detrimental health risks that an athlete could face through such modifications. These arguments are part of broader perspectives that argue on behalf of human enhancement in sport, which have gained prominence in recent years (Miah 2004).

Conclusion

The ethics of performance enhancement in sport are operationalized through WADA as a principle of "strict liability", which deems that any positive anti-doping test means immediate suspension pending an inquiry. Yet, there are many biotechnological modifications that the sports world does not address, such as functional elective surgery. To this extent, questions remain about how genetic and molecular modifications or knowledge should be treated in the long term. Arguably, as humanity's continued pursuit of health progresses, it will become apparent that the use of such science implies seeking to alter those biological processes that are a part of the aging process, and our intervention ultimately will ensure a collapse of the distinction between therapy and enhancement. If societies accept such continued pursuit, then the attempts to maintain sport as an environment free from enhancement will not simply be impractical or undesirable, they would also contravene fundamental human rights.

To this end, as the sports world races ahead to criminalize doping practices and treat the

widespread use of performance enhancement as a broad public health issue, it will need to consider the interface between the local, national and international policy debates. Arguably, the political history of sport in the post-war period ensured that genetic science would be treated as a questionable technology for sports, where gene doping would become an integral part of the war on drugs. Yet, as the American Academy of Pediatrics (2005) noted, young people are not using steroids just for competitive sport. Rather, there is a broad culture of enhancement that underpins the use of technology. In time, genetic modification may become a part of this culture, though its integration within society will emerge first through applications that are medically justified and sports have yet to resolve how they will address the genetically modified athlete that society deems to be medically permissible.

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[i] Of course, this is not a perfect system and it has been apparent that the Sports Federations have also been subject to external pressures, particularly with regard to the timetabling of sports during mega-events like the Olympics. To this end, it is misleading to suggest that the rules are set entirely by the sports community, absent of any political influence.

[ii] Additionally, various authors have identified the unintended consequences of sport technologies, which may have been designed to make competition safer, but which have had the opposite effect (Gelberg 1995).

[iii] See various essays in the SAGE journal *Public Understanding of Science*.

[iv] As some indication of this, the nanotechnology debates 10 years later have endeavoured to undertake more sophisticated approaches to public engagement via NanoJurys and the like.

[v] The declaration emerged as part of WADA's second landmark meeting on gene doping.