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Human Enhancement in Sports

Andy Miah*
University of Salford, Manchester, UK

Abstract

This chapter examines the range of sciences and technologies that converge around sports and the implications of this for issues of fairness and ethics. First, it outlines some of the recent scientific developments that speak to the convergence of disciplines pertinent to sports enhancements. Second, it considers the consequences of convergence within sport, inquiring into the practical ethical issues it provokes. Finally, it explores examples of technological effect in sport, which, collectively, articulate how far ranging are the many ways in which innovation converges on sports. In so doing, it provides a taxonomy of innovations which reveal the complexity of technological change in sports and the challenge of isolating artifice from nature.

Introduction

In 2008, a Paralympic champion named Oscar Pistorius launched a campaign to claim his place as an athlete in the Beijing 2008 Olympic Games as well as the Paralympic Games. As a performer and activist, he was unrivaled in this aspiration and he quickly became a symbol for a new generation of prosthetically enhanced athletes, whose capacities were beginning to rival those of their biologically enabled competitors. It would seem, very soon, that prosthetics would surpass biology, at least insofar as physical performance was concerned, and this period provided a clear indication of how convergence in scientific and technological innovation around sport would change the practice of performance optimization irrevocably.

However, Pistorius' campaign came to a halt quickly, as his initial request to the IAAF was turned down, on the basis that his prosthetic "cheetah" legs contravened their rules. In response, he contested this claim and, some weeks before Beijing 2008, his appeal to the Court of Arbitration for Sport was upheld, and he was given the chance to qualify and compete at the Olympic Games. In the end, Pistorius did not reach the qualification times necessary for selection in Beijing, but, 4 years later, at the London 2012 Olympic Games, he repeated the process and became the first bionic athlete to compete at the Olympic Games, making history in the process.

His example illustrates how, over the last decade, innovation in prosthetics, drug design, genetics, and simply sports science and medicine have had a dramatic impact on how one makes sense of performance capacity and enhancement in sports. After nearly 100 years of sports doping, the World Anti-Doping Code (2009) now encompasses a wide range of methods that reflect the expansion of doping techniques. These include anabolic agents, hormones, beta-2 agonists, agents with antiestrogenic activity, diuretics and other masking agents, oxygen transfer enhancers, chemical and gene doping, stimulants, narcotics, cannabinoids, glucocorticosteroids, alcohol, and beta-blockers. However, there remain numerous enhancement practices that extend beyond what the code covers, and understanding how these technologies are

*Email: @andymiah.net

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integrated with elite sports practices is essential to coming to terms with how risk is negotiated by athletes around physical excellence.

These conditions of elite sport reveal how they have become playgrounds for convergent technological innovation, where a range of applications demonstrates how sports are embedded within technological structures. The prospects for even more radical technologies to influence athletic performance grow continually as progress in nanotechnology, stem cells, and genetics gains strength. This growing role of technology within sport raises questions about its future direction, particularly how, as Kelly describes it, biology will relate to the "new biology of machines."

At the heart of these debates are key societal questions over what kinds of people there should be and what kinds of enhancements technology should allow. Moreover, one of the pivotal questions surrounding sports is whether the approach to doping needs radical transformation, as the age of enlightenment gives way to an age of enhancement, and this chapter addresses this proposition by exploring the ways in which science and technology converge to usher in an age of enhancement. To this end, the expansion of human enhancement within society also suggests the need for further convergence in sport ethics and bioethics, as the two become mutually dependent on developing insights into what kinds of lives are worth living and what kind of social systems are possible to justify from the perspective of social justice. If simply taking a pill can enable achievements or modifying genes, then the entire system of merit collapses, calling into question how goods are distributed, how achievement is attributed, and how value is ascribed to the things people do.

This chapter examines the range of sciences and technologies that converge to make sports an exemplar of innovation and progress in convergence. First, it outlines some of the recent scientific developments that speak to the convergence of disciplines pertinent to sports enhancements. Second, it considers the consequences of convergence within sport, inquiring into the practical ethical issues it provokes. Finally, it explores examples of technological effect in sport, which, collectively, articulate how far ranging are the many ways in which innovation converges on sports.

The Converging Sciences of Performance Enhancement

While it is often tempting to consider the most high-tech examples of performance enhancement in sport as a way of addressing future implications, perhaps the most important examples are found within the science of performance itself, or what might be more adequately called sports science, which is often focused on much less technological issues, such as the importance of hydration. Yet the frame of reference is even broader than this and extends to any form of technical underpinning that can influence an athlete's performance. Thus, technical enhancements include those that involve knowledge-based insights, which can lead to improved performance. Such examples encompass modifications arising from scientific insights, such as better understanding about the effect of nutrition. However, they also include the way that knowledge affects our understanding of technique. For example, in the 1960s, the Fosbury flop transformed high jumping in such a way as to alter what we now understand by this athletic endeavor. These insights can sometimes arise from spontaneous discoveries, though the expansion of sports science has led to the careful design of such transformations (Busch 1998).

In some respects then, the history of sports science is a history of scientific convergence, as more and more disciplines come together to generate insights into the technological system that is human performance, where physiology, psychology, nutrition, anatomy, physics, engineering, medicine, and more come together to optimize performance. Of course, improvements derived from new scientific knowledge are rarely controversial, though often this is because their use does not imply any misuse of medical technology, which is a primary concern of the anti-doping authorities. Yet such examples are forms of

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enhancement, and their development dramatically affects fair competition. In this sense, technological convergence makes sports possible, and the ongoing desire to enhance performance reinforces this dependency.

It is not only in-competition technologies that matter when considering convergence in sport. Some of the most interesting examples of technical enhancements involve training systems aimed at improving performance, one recent example of which is the hypoxic chamber (Levine 2006; Loland and Murray 2007). Hypoxic training is a long-established tradition of athletic competition and involves athletes moving from one altitude to another to optimize performance. However, hypoxic *chambers* are a relatively new technology that simulates this effect, while remaining in one location. The science of hypoxia involves changes in the partial pressure of oxygen within an environment, which increases the body's hematocrit level. These changes reduce the partial pressure of oxygen in the pulmonary capillaries, which leads to an increased need to breathe. In turn, the body senses the changes and increases the production of red blood cells, which are rich in oxygen-carrying protein (hemoglobin). This enhanced production leads to a greater aerobic potential for the individual.

In 2006, the world of sport debated their ethical status where concerns arose about the reliance on "expert systems" to bring about performance advantage, but it is important to note that such expertise is contested. Scientists differ on how best to utilize hypoxic chambers to promote enhancement, and so it remains a strategic choice to use, rather than a sure way of gaining an advantage. The risks posed by such chambers are also unclear, and in 2006, after extensive review, the World Anti-Doping Agency concluded that there was no evidence to suggest they are especially dangerous and they remain a permissible means of enhancement. Yet the more intriguing characteristics of this issue relate to the ethical debate that has ensued.

During 2006, the ethical status of hypoxic chambers was put to the recently formed Ethical Issues Review Panel in WADA, which is chaired by Thomas H. Murray. The panel's report raises a number of specific arguments as critical to the ethical status of hypoxic training, beginning its discussion paper by asking what it is about sport that people find honorable, admirable, and beautiful. Their position concludes that hypoxic training is a violation of the "spirit of sport" (WADA Code) insofar as it does not require the "virtuous perfection of natural talents" matters to sport. In short, their view was that the use of such chambers was "passive" requiring no skill, knowledge, or effort on the part of the athlete. They state: "my responsibility for my performance is diminished by technologies that operate upon me, independent of any effort on my part." As was mentioned earlier, the "spirit of sport" concerns constitute only one element of the process by which a technology might be deemed a doping technology. Yet, in this case, it was the first major case where the ethical perspective was seen as being potentially decisive to the overall outcome, since the health risks surrounding hypoxia were unproven. The final outcome of this inquiry made in September 2006 was that the hypoxic chambers should remain legal, which seems satisfactory to a number of commentators who challenged the proposal to prohibit their use (Levine 2006). However, an exploration of its reasoning elaborates on how categories of effect are articulated in moral language within discussions surrounding performance enhancement in sport. Whether or not the risks are significant, the case illustrates how even rest may be seen as a form of performance enhancement and how sport science must draw on scientific research across a whole range of subjects to fully understand how best to optimize physical performance capacities in competition.

Another less known technology is the "Glove," developed by Heller and Grahn. This innovative cooling device has been utilized by the San Francisco 49ers, and it demonstrates the blurred boundary between therapeutic use and enhancement. The problem addressed by this technology is overheating during exercise, which significantly diminishes performance. The Glove device "is used to apply a 35- to 45-mmHg subatmospheric pressure to an entire hand to draw blood into the hand and increase the filling of the venous plexus underlying the palmar surface. A heat sink applied to that palm extracts heat and

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cools the venous blood" (p. 972). Research on trained persons – military, sportspersons, and emergency services – demonstrates between 30 % and 60 % enhancement of endurance capacity after use. This means that the subject can work for an additional 30–60 % before exhaustion through overheating when working at maximal load. Presently, such a device is not of immediate concern to the World Anti-Doping Agency – and there are many devices that attempt to address overheating – though it remains to be seen whether similar such devices will soon be part of the anti-doping list. Guthrie (2008) describes one of the tests undertaken by the scientists on a trained athlete:

> His routine included 100 pull-ups. One day, Grahn and Heller started using an early version of the Glove to cool him for 3 minutes between rounds of pull-ups. They saw that with the cooling, his 11th round of pull-ups was as strong as his first. Within 6 weeks of training with the cooling breaks, Cao did 180 pull-ups a session. Six weeks later, he went from 180 to 616.

The "Glove" leads us to forms of enhancement that arise from innovations in equipment design, though even this concept has expanded in remarkable ways recently. While sports have always evolved alongside technological developments, equipment has sometimes been controversial, and this often has to do with its transformative effect. For example, in the 1980s, javelins were redesigned due to the fact that athletes were becoming so capable that their distances posed a risk to spectators in the far side of the stadium. Thus, rather than change the size of the arena, the javelin was adapted. The result was an alteration of the skills needed to be a competent javelin thrower, and this meant a change in the kinds of athletes who were successful. Alternatively, there are *unintended consequences* arising from technological change. For example, the development of the plastic helmet in American football was designed to protect athletes from head injuries but was widely reported to have led to more risky behavior (Gelberg 1995).

Examples like this emphasize how difficult it is to preview how an innovation will affect a performance. As technology improves, equipment finds itself in close proximity to doping discussions. For example, swimming costumes have attracted such alarm in recent times and were, until very recently, a recurrent technological story around major competitions. The evidence base to support their enhancing properties is dubious, though the psychological edge athletes may achieve by such campaigns could be considerable. In any case, during 2009, FINA was under pressure to react to a latest costume design, the use of which a number of high-profile athletes protested. Among the protestors was Michael Phelps, the most successful Olympic swimmer of all time, who threatened withdrawal from the sport unless a ban was enforced. The outcome was a complete ban on swimsuit technology, marking the end of an era of alleged technological enhancement. Again, what interests us here is less the final decision and more the manner in which the innovation draws on a range of scientific disciplines, in this case engineering, material science, physics, and physiology.

A systems-based understanding of performance becomes even more crucial when considering biochemical enhancements, and in this area, the sport's world has continued to struggle to keep up with the range of ways in which, mostly, pharmaceutical science has led to the creation of substances or methods that athletes might use to boost their performance. Such designer steroids as tetrahydrogestrinone (THG) (Sekera et al. 2005) or selective androgen receptor modulators (SARMs) – which allow more target enhancements – continue to frustrate anti-doping authorities, reminding them of how difficult it is to stay ahead of dopers. Even nutritional supplements have been found to cause problems, especially due to poorly labeled nutritional supplements or food products (Hon and Coumans 2007). Supplements are not prohibited methods of performance enhancement, though their use is discouraged due to the quality control problem. Labeling issues continue to arise in the context of standard sports products, as in the recent cases of *Vitaminwater*, which contains caffeine, a controlled substance in some anti-doping codes, or *6-OXO Extreme*, an antiestrogenic substance used to build muscle mass. These examples also point toward the manner in which sports enhancements engage a wider population and such convergent

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sciences as *nutrigenomics* are constantly creating new areas for convergent practice in sport. In this sense, the science of performance enhancement in sport is inherently convergent, as incremental improvements to performance derive often from the insights of combined knowledge systems.

A further means by which physical enhancements are achieved is through elective surgical procedures. For instance, leg extensions using reconstructive surgery or reparative surgical procedures that translate into improved performance capabilities are examples that beckon an age of enhancement. One example of this is laser eye surgery, which was famously utilized by world champion golfer Tiger Woods. Alternatively, injured athletes may enter into surgery in order to have a chance of returning to competition. One such treatment is Tommy John's surgery, utilized by baseball pitchers who tear their ulnar collateral ligament. Such athletes face the hard choice of never competing again or undergoing invasive surgery and strenuous rehabilitation. While in its early years, this procedure had a very poor likelihood of success, recent anecdotal evidence suggests the additional complication that post-surgery athletes are returning to the field pitching harder and faster than before they were injured. This raises questions over whether athletes may even elect for such surgery prior to injury, just to reinforce their biological capabilities. A similar proposition arises in the context of the earlier discussion about prosthetic devices. While athletes might not choose to replace a limb with a prosthetic, the strengthening of tendons and other connecting tissue may appeal.

Addressing the Consequences of Enhancement

Since the early part of the twentieth century, various sports organizations have employed an anti-doping policy, though it was 1967 when the International Olympic Committee first organized a medical commission whose primary role was to address the use of doping substances. The main concern of this committee involved the risks to health that doping entailed for athletes, which, expectedly, was also seen to work contrary to the values of Olympism. In particular, the televised death of Tommie Simpson in the Tour de France in 1967 began a cultural turn in how the doped athlete was represented. His image of a doped athlete has become characteristic of the abjection associated with unnatural enhancements, which, I suggest, sustains part of the political will surrounding anti-doping. In 1998, the Tour de France again was monumental in transforming this political landscape. The images of athletes under siege by police provoked the world of sport to rethink its approach to doping, and the World Anti-Doping Agency (WADA) was born soon after.

The current international standard for doping technologies is outlined in the World Anti-Doping Code, which indicates that two of three conditions must be engaged in order for a technology to be *considered* for prohibition from sport. These consist of the following:

1. Is the technology harmful to health?
2. Is it performance enhancing?
3. Is it against the "spirit of sport?"

Determining whether these conditions are engaged is not simple and requires some form of discursive process to resolve. However, it is important to realize that the code is not engaged for all forms of technological enhancement. For instance, when a new design element of a tennis racket is introduced – such as the use of piezoelectric dampening technology – the anti-doping code is not engaged. Rather, the specific sports federation will consult its own guidelines on technical specifications to determine whether the innovation is acceptable. This is important to bear in mind, as it has specific implications for how one theorizes the importance of convergence. For instance, if equipment

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modifications rely increasingly on technologies that resemble more nature than artifice – as may be said of prosthetics – then the separate spheres within which the ethics of any given enhancement is considered may need a closer proximity.

Since its beginning, one of WADA's key roles has been to harmonize policy across sports federations. Since its inception in 1999, it has succeeded in working with UNESCO to develop a convention on doping, and its relocation to Montreal has been accompanied by renewed efforts from a range of countries whose recent actions suggest greater rather than less controls over athletes' actions. In particular, former US President George W. Bush included references to the "war on drugs" within two State of the Union addresses (2004 and 2005). Also, over this period, a series of congressional hearings took place in relation to doping within baseball, which aimed to address the prevalence of substance use within youth culture. Yet, also during Bush's presidency, critics alluded to a need for more careful consideration on how best to tackle the use of performance-enhancing substances in sport. At a time when the USA was beginning to introduce anti-doping tests within a number of high schools, it is pertinent that the American Academy of Pediatrics (AAP 2005) published a statement questioning the effectiveness of such tests as a deterrent.

Other activities within the USA were also relevant for raising the political profile of sports enhancement issues. For instance, during 2002 the US President's Council on Bioethics received two sessions, which discussed enhancement in sport (2002a, b). Also, the leading bioethics institute, The Hastings Center, undertook continual research in this area since the 1980s (Murray 1983, 1984, 1986a, b; Parens 1998), later receiving funds from the US Anti-Doping Agency to explore the possible misuse of genetics in sport. Projects taking place at The Hastings Center during these years have been pioneering in terms of sport's commitment to funding ethical research. In 2006, Murray was also appointed as chair of the new WADA Ethical Issues Review Panel, which, also in 2006, made its first substantive intervention by concluding that the use of hypoxic environments (also known as altitude chambers) should be deemed an infraction of the WADA Code because they violate the "spirit of sport." These developments speak to the growing convergence between sport ethics and bioethics, as suggested earlier.

Other recent historical moments have been critical in shaping the current political landscape of anti-doping. In 2003, the now infamous Bay Area Laboratory Co-Operative (BALCO) affair reminded anti-doping authorities that designer substances are completely unknown and it will be near impossible developing direct tests for them in advance without substantial collaboration between the anti-doping authorities and drug developers. Indeed, the challenge of proving positive doping cases has been one of the major obstacles for anti-doping authorities. This challenge has also recently given rise to changes in the law, where the emergence of a nonanalytical positive – a doping infraction without the need for a urine or blood test – means that athletes now face possible disqualification (and sometimes prosecution) based on evidence other than unequivocal facts. These circumstances are also accompanied by an emerging willingness to criminalize doping infractions and to discuss doping as underpinned by an international criminal drug mafia (see Donati 2005). These terms reshape what is at stake in the issue of doping, transforming a matter related to fairness and ethics in sport to a moral panic over drug use. An additional facet to this debate is also greater willingness to recognize the broader use of illicit substances, which are typically associated with sports performance. The AAP notes that many users are not elite athletes at all, but young people who are preoccupied with body image.

This final point alludes to the relevance of broader cultural studies of body modifications when considering the use of enhancement technologies in sport. While it is tempting to believe that the rationale for any athlete's use is merely to gain an edge over other competitors, other values are engaged. Yet related studies of the cultural context of performance enhancement are often overlooked in the debate about the ethics of sporting performance (Denham 1999a, b) (in 2006, WADA opened a tender for social science studies of doping). For instance, while there is considerable reference to how the media characterize the doping debate, very rarely is this media presentation taken into account in policy discussions. Thus, one

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could be skeptical of the claim that society broadly is unhappy about *enhanced* athletes. Rather, one might more adequately claim that the media discourses surrounding the *doped* athlete generate a justification for a culture of anti-doping (Magdalinski 2000).

Evidence of convergence in how sport addresses the problem of enhancement is apparent within the activities of key legislative agencies and advisory committees. The current US President's Council has focused considerably on "enhancement" or, perhaps more accurately, emerging technology issues. Its landmark publication *Beyond Therapy* (U.S. President's Council on Bioethics 2003) engages with some of the issues faced by the world of sport in the context of enhancements. Alternatively, in 2003, the Australian Law Reform Commission (2003) published an extensive document on the use of genetic information within a range of social contexts, one of which includes sport. More recently, the UK Government Select Committee for Science and Technology launched a public inquiry into the use of Human Enhancement Technologies in Sport (Science and Technology Select Committee 2006). To this extent, it is useful to employ our convergent metaphor in the analysis of converging legislation surrounding human enhancement technologies. Nevertheless, of critical value is to understand how a range of technological systems affect the conditions of elite sport and how these conditions are also intimately reliant on multiple knowledge systems.

Safety and Harm

One of the central aims of technological change in sport has been to improve safety and reduce the risk of harm. Many rule changes within sports can be viewed as *technologies of knowledge* that aim to restructure the range of technological interactions – such as the foot against the floor or a shoulder's movement when swinging a racket. Other examples include the redesigning of the javelin in the 1980s, when athletes were throwing dangerously close to the spectators. The only reasonable solution to this impending problem was to change the specifications of the javelin so that the athletes could not throw it as far. This resulted in a change in the kinds of athletes that were successful as javelin throwers, from the strongest to the technically proficient. Other examples include:

- Improved floor surfaces within sports halls to reduce shock to athletes when landing or bounding (Bjerklie 1993)
- Introduction of plastic helmets in American football to reduce head injury (Gelberg 1995), later improved by the introduction of helmet concussion sensors, such as Shockbox (see http://www.theshockbox.com/football-sensors) and xPatch (http://www.x2biosystems.com/)
- More sophisticated shoe design for more support to foot during athletic events
- Increased wicking qualities in clothing to protect climber or mountaineer from the cold and rain
- Springboard surface in diving to prevent slip and increase resiliency of board tips to reduce injury (Bjerklie 1993)
- Sturdier épée and foil in fencing as well as Kevlar jackets for more protection but with no loss to movement (Tenner 1996)
- Navigational equipment in sailing (Inizan 1994; Tenner 1996)
- Carbon composite poles in pole vaulting and enhanced safety pits, allowed more daring contest and higher vaults (Bjerklie 1993)

These examples identify the imperative for sports federations or governing bodies of sport to strive for their practices to be less dangerous for the competitors by introducing new technological measures. However, they also show how insights of this kind rely on a complex set of knowledge systems, which encompass visual data capture, data analysis, material science, and psychology, for instance. In this

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respect, convergence in sport is parasitic on other convergent practices but may also give rise to new technological applications that can be utilized in other spheres.

De-skilling and Re-skilling

Technological innovations can also alter the way that sports are played. They can change the conditions of training that are required to be successful at a particular skill and can even make it easier to perform the required skills. Examples of such technologies include:

- Zepp sensors, used in baseball, tennis, or golf – a mounted sensor, which reads and evaluates swing; see https://www.zepp.com/ (2015).
- RideOn Augmented Reality Goggles; see http://www.rideonvision.com/ (2015).
- U-grooved golf clubs that allowed greater accuracy on stroke (Gardner 1989).
- Depth finders in fishing to make it easier to locate large schools of fish to enhance prospects of catching (Hummel and Foster 1986).
- Superman cycling position that allowed more streamlined position for greater speed (Fotheringham 1996).
- Breathable clothing material used to regulate body temperature in extreme climates (Miah 2000a).

The PGA's reasons for disallowing the "square" or "U-grooved" irons from golf in 1990 reflect how technology can alter the kinds of skill required of an athlete (Gardner 1989). Gardner describes how tour players considered that the clubs gave the golfer an advantage by creating a higher spin rate, which translated into better ball control. Some tour professionals had been opposed to their use because of a concern that they "devalue true golf skill and consolidate their talent" (p. 69). Similarly, Hummel and Foster (1986) recognized that the "spinning reel" in fishing "virtually eliminated backlash in casting and thus the necessity of an 'educated thumb' to act as a drag on line being cast" (p. 46). Thus, the innovation was considered to have democratized the skills of the sport and had devalued or de-skilled the activity. While these devices would seem quite useful for a novice who may require assistance to engage in the activity in a meaningful way, their application to competitive sports is implied – yet it is unclear that such things are beneficial within elite competition.

Additionally, it is not representative to argue that these technologies necessarily de-skill a sport. It may also be argued that technological changes in sports "re-skill" an activity. In explanation of "re-skilling," one may consider the controversial "superman" cycling position introduced by Graeme Obree in 1995. The position entailed the arms of the cyclist being placed in front of the face and the seating post being unusually high, thus making the position more aerodynamic. Thus, while the skill had not been made any easier, it had altered the bicycle such that it did not resemble conventional cycling positions (it had been re-skilled and it made it possible to achieve more without any greater physical capability). Interestingly, the International Cycling Union (ICU) made this very argument when legislating against the use of the position. In concluding their stance on the "superman" position, the ICU argued that the technical developments had "obscured the physical demands made by cycling, and had made it harder for the man on the street to identify with elite cyclists" (Verbruggen cited in Fotheringham 1996, p. 23). Despite such claims, it might be wondered how the ICU justify the acceptance of methods of design and construction of bicycles that are more comparable to the design of an aircraft than an "everyday" bicycle. It would seem possible to argue that, on similar grounds, the use of such materials also makes the bicycle unacceptably different from a preconceived notion of what is a bicycle.

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Dehumanizing and Superhumanizing

The cycling example raises a more complicated question about whether an athlete can claim responsibility for any performance achievement and puts into question whether the human athlete or the technology has achieved the performance. However, to answer such a question requires being able to make clear distinctions between them. This category presumes that something clear can be said about humanness that is lessened or removed by the use of some technology. This categorization might be criticized for bringing together two quite different claims about a technology that are not at all oppositional. Indeed, the elite athlete might both be dehumanized and superhumanized by a technology.

Nevertheless, the purpose of this categorization is to demonstrate ideas about the moral implications of technology so as to identify the kinds of argument that are being made about the effects of technology. In this sense, dehumanization is justified in as much as researchers of technology have made such claims. Some examples that have been (and might be) seen as reflective of dehumanizing/superhumanizing technologies are as follows:

- Doping and drug taking (Hoberman 1992; Fraleigh 1984).
- Genetic enhancement (Miah 2000b, 2004; Munthe 2000).
- Springboard in diving allowed divers to gain more height on dive (Bjerklie 1993).
- Fiberglass archery bows, more resilience and more consistency (Bjerklie 1993).
- Plastic/metal composite discus allows longer throw.
- Barbells are now stronger with some flexibility to allow the lifter to use more techniques when lifting and drop bar at the end of lift to save strength (Bjerklie 1993).
- Kevlar and carbon fiber kayaks are lighter, more sturdy, and easier to maneuver.

While various authors discuss how these technologies alter what it means to be human, adding content to such claims is more problematic as identifying the salient characteristics of humanness that are removed or lessened by such technology is not easy. Nevertheless, if one is to place any credit at all in these, at least, intuitions about technology, then it is worth considering the possibility that they are not consistent with the characteristics of humanness. If one is not convinced that these technologies do, in fact, dilute human qualities, then it can be useful to discuss whether any kind of technology could be a threat to humanness. Would, for example, a human that is largely a mechanoid be a challenge to humanness? If not, then is a robotic human, one whose mental capacities are formed by some artificially intelligent computer, a threat to humanity? If such beings can be seen as a challenge to humanness, then there might be some grounds for concern. Where this line is drawn is less important than the possibility that it could be crossed, which, I suggest, is often the basis on which anti-doping policy is justified (i.e., there is an imperative to draw a line somewhere).

Increase Participation and Spectatorship

One of the major interests of a sports governing body is to maximize the breadth of inclusion within the given sport. This ambition often translates into the development of technology that can allow a sport to become more accessible to prospective participants. The example is slightly different from developing technologies to make the sport easier, as the main aim here is the maintenance of standards, with the broadening of participation. Alternatively, equipment is often developed that can even exclude particular kinds of individual from participation. For example, the sophistication of technology demands a level of finance that is beyond many individuals. Examples of such technology include the following:

Q8
- The Babolat connected tennis racket, with built-in sensors and a mobile app to provide feedback on performance and a social network for sharing (see http://en.babolatplay.com/)

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- Artificial turf for field sports (Tenner 1996)
- U-grooved golf clubs (Gardner 1989)
- Carbon composite tennis rackets and mass production of other kinds of equipment (Brody 2000)
- The carving ski (alpine) that makes it easier to learn skiing
- Different sized tennis balls (Miah 2000c)
- Varying speeds of squash ball for different levels of competence

The value of such technology is not difficult to understand from a commercial perspective. The ability to reach a wider audience can seem a worthwhile ambition. However, the consequences of such ambitions are not uncontroversial for some sports. For example, in sports such as climbing or skiing, there exist limited natural resources, the overuse of which could seriously damage the environment and lessen the aesthetic experience of the performance. If mountains were overrun with climbers and skiers, they could lose their tranquil characteristics, which would seem to entirely contradict what is valuable about these activities. Along these lines, it is not at all clear how big would be big enough for sports. While the ambition for widening participation is admirable, its justification tends to be more financial than moral. Yet the exploitation of a sport simply to widen participation and generate more financial resources seems ambiguously beneficial.

These varied examples provide some basis for understanding the complexity and effect of technologies in sport and the range of values that are engaged when considering the ethical implications of any proposed technological innovation. In addition to these effects, one must also recognize that there are further concerns about the unknown consequences of new technologies. Indeed, it is crucial to recognize how anti-doping authorities develop policy on the basis of lacking scientific evidence that can demonstrate safety.

Transhumanist Technology

As a final consideration on scientific convergence in sport, the utilization of genetic technology is valuable to consider, as research around genetics can inform our understanding of performance capacities and predispositions. Currently, research implicated for gene doping includes modifications to growth factors such as IGF-1 (Barton-Davis et al. 1998; Goldspink 2001; Lamsam et al. 1997; Martinek et al. 2000), PGC-1alpha (Lin et al. 2002), recombinant EPO (Svensson et al. 1997), and the so-called ACE gene (Brull et al. 2001; Gayagay et al. 1998; Montgomery et al. 1998, 1999).

The rise of genetic technology marks a new paradigm for anti-doping policy makers because it presents a new landscape of ethical issues, political views on enhancement, and concerns, along with new techniques to detect doping. While many applications of gene doping have yet to materialize, the science of genetics is seen as a vehicle through which discoveries can be made to make anti-doping more robust. Furthermore, genetics has entered the public domain already in sport through the creation of performance gene tests, the first of which was released commercially in 2004. One year later, the WADA (2005) announces in its Stockholm Declaration on gene doping that such tests are to be discouraged. In this sense, genetics is symbolic of a science that progresses faster than society can keep up with it.

Conclusion

In April 2015, the weight loss food company Protein World launched a billboard campaign depicting a toned young woman wearing a bikini with the headline “Are You Beach Body Ready?” The campaign

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caused considerable controversy and was eventually banned by the Advertising Standards Authority in the UK after receiving 360 complaints claiming that "the ad is offensive, irresponsible and harmful because it promotes an unhealthy body image" (Sweney 2015). The basis of the suspension was the legitimacy of the claims made in the advert, namely, that "Substituting two daily meals of an energy restricted diet with a replacement meal, contributes to weight loss." Whether or not this claim is substantiated, the example is pertinent here, as it reminds us that – in line with the AAP's conclusions – the pursuit of an athletic body is not the exclusive interest of athletes. Rather, there is a wider culture of human enhancement that provides buoyancy to the enhancement industries, of which sport is a part. Whether the approach is using protein diets to reduce weight, or using surgery to stable stomachs, the pursuit of human enhancements is complex, contested, and subject to all kinds of ideological impositions.

What unifies the examples of enhancements I have considered is their utility for activities beyond sport. One can imagine numerous forms of labor that would benefit from greater endurance, strength, or ability. Elite sports have always been a test space for enhancements, and their rule-governed nature offers a useful structure through which to address how questions of justice would be played out within an enhancement-led society. Yet it is also apparent that enhancement is not just a functional quality, as many such modifications are utilized to improve appearance as much as performance.

The key challenge for enhancement advocates is to bridge the ethical gap between therapy and enhancement, to reach a point where new medical products can be developed and characterized for use by healthy subjects. While it is apparent that the medicalization of various conditions may be leading to this situation, an explicit shift in how medicine progresses will be necessary before a strong enhancement culture can emerge. Many forms of enhancement rely on the use of therapeutic technologies, which bring about transformations in the concept – such as the use of stem cells to promote tissue repair (Templeton 2006). As these technologies begin to arise, an increasing number of questions will emerge about whether sports can stem the tide of enhancements alone, or whether broad social structures will intervene. Once the convergence between therapy and enhancement is complete, then society may be better placed to address the opportunities and limitations of human enhancements, in sport or outside of it.

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