Physical Enhancement: The State of the Art

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In June 1969, *Sports Illustrated* outlined the state of the art in doping technology. At the time, global concern about sports doping was just beginning, but what has changed in the 40+ years since then? There is still considerable uncertainty about whether many substances actually enhance performance and there is still little known about the health risks posed by doping methods, as there is nearly no evidence base detailing the utilization of medical products by healthy, trained athletes. There is also an absence of evidence about how the medical supervision of doping methods might affect this risk, both by allowing more insight into its management and by ensuring that the products themselves are from reliable distributors, rather than illegal markets.

Similarities between then and now are also apparent in the moral equivocation about lifestyle modifications. While the sports movement generally focuses on doping methods that affect fair competition, cases such as that of American swimmer Michael Phelps in 2008 who was photographed smoking marijuana raises further questions about whether the role of sports organizations also extends to regulating moral behavior outside of sports' primary concern. In such cases the common ground is also to do with whether lifestyle drugs have an effect on performance, and discussions about alcohol today.

Gilbert (1969) also inquires into whether the concern about physical enhancement in sport should be seen as a matter of public interest, rather than private sport concern. To support this case, the American Academy of Pediatrics (2005) outlined that enhancement was a broader cultural phenomenon where body boosting for *performance* or *appearance* were both major factors in what led young people in particular to enter into off-prescription substance use.

Today, the World Anti-Doping Code (2009) encompasses a wide range of methods that reflect the expansion of doping techniques. These include anabolic agents, hormones, beta-2 agonists, agents with anti-estrogenic 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 integrated with elite sports practices is essential to coming to terms with how risk is negotiated by athletes around physical excellence.

This chapter examines the state of the art of physical enhancement, demonstrating how the problem of regulating excellence is becoming more difficult as technology advances. Modifications are grouped into the following categories, building on Ellul's (1964) seminal discussions on philosophy and technology: *technique, equipment*, and *biology*.

Technique

Technical enhancements are those that involve knowledge-based innovations, which 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).

Modifications of this kind do not tend to attract the interest of doping authorities, 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, they are forms of enhancement and their development dramatically affects fair competition. An example that occupies the mid-point between such innovations in technique and medical intervention is the hypoxic chambers (Levine, 2006; Loland & 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. 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.

Another emerging 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 cools the venous blood” (p.972). Research on trained persons – military, sportspersons, 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.

Equipment

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 affects 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 process through which the decision took place, which did not involve the arena of anti-doping concern at all. Instead, judgments arose from within the swimming federation's technical rules commission. Historically, equipment and biological enhancements have often been completely separate debates, yet they raise similar philosophical issues (Miah, 2005).

Prosthetic devices

The expansion of equipment to prosthetic devices is also provoking new philosophical questions about what constitutes athletic performance. In 2008, the world-record breaking South African sprinter Oscar Pistorius campaigned to take part in the Beijing Olympic Games as well as the Paralympic Games. A double below-the-knee amputee, Pistorius is able to attain sprint times that approximate athletes competing in the Olympic Games. His achievements reflect the convergence between Olympic and Paralympic athletes that is brought about by prosthetic devices. While Pistorius did not succeed in 2008, it is likely that he will be the first of many athletes who are able to compete at Olympic level. The reason for this is relatively simple: as prosthetic technology improves, it reduces the performance inhibition arising from the technology, slowly creating a device that seamlessly approximates the capacities of a human leg. When this reduction is optimized, Paralympians will be competing on the same biomechanical basis as Olympians and it is likely that we will see even greater challenges to biology as the exemplar of human excellence. However, the major problem for sports is what may happen when the devices *exceed* the capacities of their biological counterpart. In such an era, it may signal the end of biologically governed

sports performance.

Biology

Prosthetic devices articulate how biology and artifice intersect and, while all of the previous examples affect an athlete's biology in some way, perhaps the most controversial physical enhancements arise from interventions that alter an athlete's biology from the inside. The methods by which this is achieved vary considerably, as do the risks. My final section offers insight into some of the major, emerging biotechnological enhancements that affect physical capabilities. Together, they articulate the challenge faced by regulatory authorities – both sports and medical – as greater demands are placed on the medical industries.

Designer steroids

[In 2003, a phial filled with an unknown substance was left by an unknown individual at the U.S. Anti-Doping Authority laboratory. Upon analysis, it became characterized as a designer steroid called tetrahydrogestrinone (THG) and its discovery led to the BALCO scandal, which saw the demise of high-profile U.S. athletes Marion Jones and Tim Montgomery among others. THG demonstrated that so-called designer steroids pose one of the major challenges to the world of sport (Sekera *et al.*, 2005). While in many ways similar to traditional steroids, what distinguished THG – and other designer steroids – was the fact that it was not a substance available commercially and, as such, very little could have been known about it in advance of its discovery. No authorities were testing for it in sports, as they did not know it existed. This shift from steroid use that arises from the nonmedical use of medically available products to a situation where doping communities are developing their own products on the basis of pre-clinical data, changes what anti-doping authorities must do to keep up with dopers. Now, there is more need than ever to ensure that anti-doping authorities are not just studying what is available, but that they have access to research at the developmental stage.

Additional scientific advancements in steroid-like enhancements arise through SARMs (selective androgen receptor modulators), another emerging enhancement. Through the use of SARMs, athletes may be able to target specific tissue more effectively, avoid having to use injections, and can minimize some of the side effects common to steroids, such as conversion to estrogen or the inhibition of naturally produced testosterone.

Nutritional supplements, customized vitamins, and functional foods

While various forms of drugs clearly engage various authorities, the use of nutritional supplements by athletes is much more ambiguous. However, they have been a matter of concern for to the sports world for over 10 years and, in the 1990s, it was commonplace for athletes to attribute positive tests to poorly labeled nutritional supplements or food products (Hon & 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 anti-estrogenic substance used to build muscle mass.
Additionally, *nutrigenomics* is creating a new generation of functional foods, whether through enhancing crop properties or by feeding animals with enhanced diets that will, in turn, enhance humans through their consumption (Twine, 2007). Again, the overlap between sport and society at large is central to understanding the challenge arising from the regulation of such products in competitive situations.

Elective surgery

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 suggest 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.

Growth factors

The utilization of growth factors and hormones has been commonplace in sports for many years particularly through human growth hormone (HGH), which is used to promote the secretion of insulin-like growth factor 1 (IGF-1), which can play a role in muscle and organ growth. Side effects of HGH can include diabetes, “worsening of cardiovascular disease, muscle, joint and bone pain; hypertension and cardiac deficiency; abnormal growth of organs; accelerated osteoarthritis” (World Anti-Doping Agency, 2009). While developing a test for HGH has taken some years, recent science proposes utilizing nanotechnology to identify the substance (Shipley, 2008). Moreover, a “marker method” (Stow *et al.*, 2009) is becoming a preferred anti-doping method for the indirect detection of a number of new substances. Other growth factors, such as vascular endothelial growth factor (VEGF), can be used to enhance blood vessels, allowing more oxygen to muscles.

Pain modulation

Enhancements often provide their advantage by addressing the debilitating physiological effects of extreme exercise, as for the glove. However, there are also biochemical mechanisms through which pain may be managed to enhance physical performance. One candidate is Downstream Regulatory Element Antagonistic Modulator (DREAM), which is a “critical repressor for pain modulation” (Cheung, 2002 January 11). Recent research suggests that DREAM could provide useful information about the function of pain and how it might be managed, which could revolutionize how pain is addressed by medicine (Cheng *et al.*, 2002; Cheng & Penninger, 2003). The DREAM protein functions by blocking the production of prodynorphin (the precursor to dynorphin, an endogenous analgesic), which is a chemical produced in response to pain or stress. Research with mice suggests that the absence of DREAM (the gene) leads to increased levels of dynorphin and a decreased sensitivity to inflammatory, acute, and neuropathic pain.

Blood boosting

A range of methods of performance enhancement involve the manipulation of blood, particularly the boosting of red blood cells to improve oxygen delivery, which promotes endurance. Early forms of blood modification include the practice of blood transfusions, which, in the 1960s, was not a banned method, due to a clause in anti-doping law that

required a test to be available in order for a method to be banned. Since the removal of this clause, blood doping has gone through various histories of use. Most recently, autologous blood transfusion has become prominent, often using *dry blood* that is extracted, frozen, stored, and then reintroduced to the athlete's blood stream.

Since its emergence in 1989, recombinant human EPO (rHuEPO) has become a popular drug through which to boost endurance, though a test for its detection has led to the creation of various forms, such as CERA (continuous erythropoiesis receptor activator), which does not require as frequent injections as rHuEPO. The risks of such use include the thickening of blood to such a degree that clots can form, increasing the chances of heart disease, stroke, and cerebral or pulmonary embolism.

Alternatively, the practice of *blood spinning* (platelet-rich plasma therapy) has become a common therapeutic device, which enhances recovery. The method involves drawing blood from an athlete, spinning it to isolate the platelets, which clot and promote healing. The platelets are then injected into the injured part of the body to repair tendons. Its status is unclear as a method of doping, but the case emphasizes how the problem of sports arises when therapeutic interventions become extraordinarily effective – arguably transforming natural healing processes.

More modest means of boosting the oxygen content are also available on the market. For example, *canned oxygen* has become prominent in some sports and is available as a recreational sports product. However, WADA has recently given notice of its prohibition as an illegal method of oxygen transfer, raising further questions about how sports regulate practices outside of elite competition. While the use of bottled medical oxygen itself is classified as a drug in some countries, recreational canned oxygen is not. Yet, there is no proven enhancement to athletes, despite its widespread use in high profile sports such as the National Football League (NFL). Similar questions arise from the present discussions about Viagra (sildenafil citrate), which is currently not a banned substance, but which may find itself on the prohibited list, due to its potential to boost oxygen levels and affect performance at modest altitudes (Hsu *et al.*, 2006). By delivering such substances via "Viagra tattoos" (Magnay, 2008) located under the skin, doping can be even harder to detect due to its slow release and low quantities.

Conclusion

What unifies these examples of physical enhancements 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, 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.

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