RUN, SWIM, THROW, CHEAT

The Science behind drugs in sport

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CONTENTS

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Prologue:
A tale of two races

The 1988 Men’s 100 m Olympic Final has been called the most corrupt race ever.[1] It took everyone’s breath away. One man ran a tenth of a second faster than any person had ever done. The world record was smashed. The world celebrated, for a day. And then the new myth fell apart. Ben Johnson, hero o all Canada, was a cheat. Though some of the offences were minor compared to his, subsequent events implicated six of the eight sprinters in that race in activities that—at one time or another—would hav them banned from winning Olympic gold medals.

I remember the race vividly. I was researching my PhD in Canada at the time, but was on holiday back in the UK. Two Canadians and a Briton were lined up in the final. I stayed up until four o’clock in the morning. Although it could be argued that I had dual loyalty between the Commonwealth allies my main desire was in rooting for the underdog. Could someone beat the seemingly all-powerful US team—in this case exemplified by the not-quite-so-humble current Olympic champion and former world record holder Carl Lewis? Ben Johnson the current world record holder and Canadian hero seemed a likely prospect, but he had barely survived the semi-final. And yet, one man won convincingly (see Figure 1).

Johnson was first in an astonishing time of 9.79 s—more than 0.1 s faster than any other man had ever run and a time set whilst celebrating victory before reaching the line. But what happened two days later shocked the sporting world, and especially Canada. Johnson tested positive for the banned anabolic steroid stanozolol, the gold medal was removed, and his career collapsed. He tested positive for steroids a second time during an abortive comeback in 1993 and was banned for life by the International Association of Athletics Federations (IAAF).

Second place went to Carl Lewis (USA) who was awarded the gold medal when Ben Johnson was disqualified. However, at the 1988 US Olympic trials Lewis tested positive for the banned stimulants pseudoephedrine, ephedrine and phenylpropanolamine. At the time the US Olympic Committee (USOC) policy was not to ban athletes for stimulant use unless it was demonstrated that there was a deliberate attempt to affect performance. Inadvertent use of herbal supplements or over-the-counter cold remedies would not result in a ban (a decision upheld by an IAAF investigation in 2003). The same defence has not worked in other sports illustrating the anomalies of anti-doping systems. For example the 16-year old Romanian gymnast, Andreea Raducan, was stripped of her gold medal at the 2000 Sydney Olympics when her coach gave her a pseudoephedrine-containing Nurofen pill as a colc therapy.

In third place came Linford Christie (UK), who in the next Olympics (Barcelona, 1992) was to become—and still is—the oldest man ever to win the Olympic 100 m title. But after the Seoul final, Christie tested positive for the same stimulant for which Lewis had tested positive, namely pseudoephedrine. By a vote of eleven to ten the International Olympic Committee’s disciplinary committee accepted his response that he had taken it inadvertently in ginseng tea. However, Christie was caught when he came out of semi-retirement to race in Dortmund, Germany at the age of 39. He tested positive for the steroid nandrolone and the IAAF banned him for two years. Christie has alway maintained his innocence of this charge.

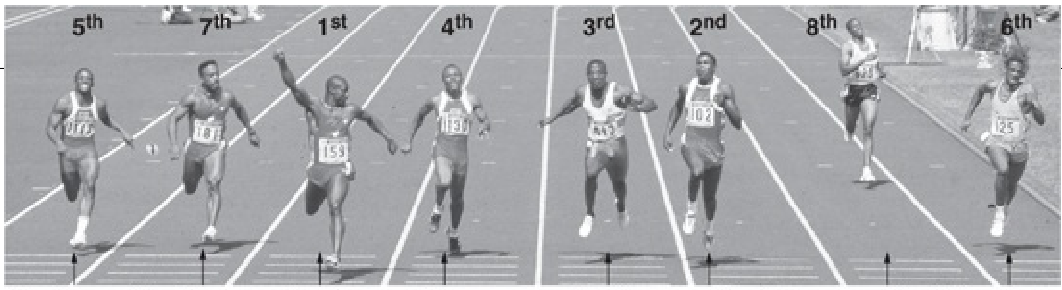

Figure 1 The 1988 Olympic Men's 100 m race in Seoul.

Subsequent events showed that six out of the eight athletes used banned substances in their careers.

Calvin Smith (USA) was fourth on the day and clean then and since. Should he have been given th gold medal? He certainly thinks so. 'I should have been the gold medallist, … If all the positives (tests) are true, I should have won.'[2]

Fifth place went to Dennis Mitchell (USA). Ten years later Mitchell was banned for two years by the IAAF for an excess of testosterone; he also admitted to being injected with human growth hormone.[3] It is not known whether he was on performance-enhancing drugs at the time of the Seoul race.

Sixth place went to Robson De Silva (Brazil), a clean athlete who had the consolation of a bronze medal in the 200 m at the same Olympics. Yet in gold and silver medal positions in that race were Jo DeLoach and Carl Lewis, both beneficiaries of the US Olympic Committee's policy on disregarding positive tests triggered by inadvertent stimulant use during the Olympic trials. If no justifications were accepted for stimulant use De Silva could have had gold and silver at these Olympics, but came away with only bronze.

Desai Williams (Canada) ran in seventh. He admitted taking steroids from September 1987 to January 1988.[4] Although Williams always denied subsequent use[5] the Dubin inquiry concluded that i was 'satisfied that Mr. Williams was using anabolic steroids not only in the fall of 1987 but also during the spring and summer of 1988 prior to the Seoul Olympics'. [4] Williams was banned for life from receiving Canadian sports funding although this ban was lifted in 2010 due to his subsequent positive behaviour. [5]

Eighth place went to Ray Stewart (Jamaica). There is no evidence that he took drugs himself in hi running career, but in 2010 he received a lifetime ban from the US Anti-Doping Agency (USADA) fo providing a range of performance enhancing drugs to the athletes he coached.

The aftermath of Seoul

Johnson's ban for taking the steroid stanozolol led directly to the Dubin 'Inquiry Into the Use of Dru and Banned Practices Intended to Increase Athletic Performance'. [4] This move by the Canadian government was the first real attempt by Western sport to publicise openly what many knew was happening in private. A host of Canadian athletes and coaches revealed the dirty tricks of their trade. It is illuminating to listen to these.[6] At the inquiry it was noted that the standard procedure after an athlete is caught doping was to 'deny, deny, deny'. For ninety-one days in a courtroom in Toronto thi ‘standard procedure’ was ignored as testimony from forty-eight steroid users—in sports as wide-ran~~ging as track-and field, weightlifting, bobsleigh, wrestling and football—filled 14,617 pages~~ of transcript. This volume of data was later matched when the Stasi files illustrating the extent of the East German doping programme in the 1970s and 1980s were revealed, following the fall of the Berli Wall. Over 2,000 athletes, including many children, were revealed to have been systematically dopec So did these events, outlining the extent of doping in the West and the East have an effect on sporting practice? Absolutely not if you listen to the athletes themselves.

It is not surprising that athletes sometimes hint that other competitors have an unfair advantage. But it is rare to name specific rivals. Whilst sprinters and anabolic steroids featured in the Dubin inquiry and the Stasi files, the early years of the twenty-first century saw several prominent UK athletes voicing their concerns about the use of a drug made infamous by the Tour de France cycling race—the blood booster EPO that helps athletes use oxygen more efficiently in long distance events.

The extent of the criticism of fellow athletes was surprising. In the 2001 World Athletic Championships, Paula Radcliffe, Hayley Tullett and Kathy Butler unfurled a banner that read ‘EPO cheats out’ as a rival athlete Olga Yegorova ran in her heats. Then Britain’s Kelly Holmes accused Slovenia’s Jolanda Ceplak after she lost to her in the women’s 800 m race at the 2002 European Championships.[7] When asked about Ceplak’s win Holmes said, ‘take your own guess [how she did it I know I do it fairly …’. Ceplak’s reply to Holmes was right out of the athlete’s ‘standard procedure’ ‘I think she [Kelly Holmes] needs to make me a big apology. She said she did it fairly, but I did too.’

So did the weight of the legal inquiries, captured Stasi files and the voluble protests of the athletes themselves have a long term effect? Let’s fast forward to 2005 to find a race that is less famous than Ben Johnson’s sprint but is every bit as indicative of the powerful hold that drugs have in sport.

The most corrupt race ever?

In 2004 the UK’s Observer newspaper claimed that Ben Johnson’s 1988 victory was the most corrupt race ever. This title was short lived. In 2005 the World Championship women’s 1500 m race was run in Helsinki. Here all of the first five athletes to cross the finishing line were found guilty by the IAAI of doping offences in their subsequent careers (see Figure 2).

Figure 2 The 2005 World Championship 1500 m race in Helsinki.

Subsequent events showed that the first five athletes to cross the line were found guilty of doping offences in their careers. Although never admitting to their guilt the IAAF bans were never overturned.

First place went to Russia's Tatyana Tomashova. Curiously, her fall from grace came because she was too good at being tested for drugs. Normally out-of-competition testers have to hunt for an athlet once they have given them their statutory one-hour notice. But they always found Tomashova ready and waiting exactly when requested. The anti-doping officials suspected she was being tipped off and though this was never proven, they were concerned enough to check previous samples. Forensic tests were used to measure the small amount of DNA in the urine samples; these showed conclusively that the samples given in a 2007 out-of-competition test in Russia did not match those given at the World Championships in Japan the same year. The DNA was from different people. She was banned for two years in 2008.

Second place would have gone to Yuliya Chizhenko-Fomenko (Russia), but she was disqualified for obstructing another athlete. She was also banned in 2008 for the same urine tampering offence as Tomashova.

Third place (later upgraded to the silver medal) was awarded to the Russian Olga Yegorova. She too provided false urine in 2007 and was subsequently banned for two years. However, her history gives us a hint as to what may have been concealed in the missing urine samples. In 2001 she had tested positive for EPO by a laboratory in France, the result that inspired the protests from Paula Radcliffe and her teammates. However, at the time the rule was that a direct urine measurement for EPO had to be backed up by a blood test. This confirmatory test was never performed so no further action was taken against Yegerova at that time.

Fourth place went to Bouchra Ghezielle of France, who was awarded the bronze medal after Chizhenko-Fomenko's disqualification. Ghezielle was later found guilty of doping with EPO in 2008 and given a four-year ban.

Fifth went to another Russian, Yelena Soboleva who was another found guilty of urine tampering 2007.

Sixth place went to the first 'clean' athlete in the race: Jamal Maryam Yusuf of Bahrain. Yusuf wa the unfortunate athlete who was physically obstructed by Chizhenko-Fomenko during the race. Justic on both accounts (doping and obstructing) was eventually done when Yusuf won the gold medal at th next World Championships in Osaka in 2007, beating the Russian Soboleva into second place.

Finally what of Jolanda Ceplak, the athlete accused by Kelly Holmes in 2001? In 2004 Holmes ha her revenge on the track, winning the gold medal at the Olympic Games and beating Ceplak into thir place. Prior to that Holmes and Ceplak appeared to have made up. Ceplak acted as a pacemaker for Holmes's attempt to run a new UK indoor 800 m record in 2003 and later helping by lecturing to students at 'On Camp with Kelly', Holmes's initiative to identify talented young runners.[8] But then i 2007 Ceplak failed a test for EPO; she was consequently banned from competition for two years by the IAAF. Had she been cheating all the time, or only turned to drugs when her career started to fall apart? Or, as she has always protested her innocence, was something wrong with the test?

The future of drugs?

There is a famous survey by Dr Robert Goldman that claims that over fifty per cent of athletes would take a drug that guaranteed them unlimited, undetectable sporting victories for five years, even if it was followed by instant death.[9] This prologue illustrates the ubiquity of drug use in sport, the extremes some people will go to succeed and the difficulty the authorities have in eradicating the problem. Even a relatively small US company—the Bay Area Laboratory Co-Operative (BALCO)—was able to market drugs to over twenty top athletes in a wide range of different sports, including Olympic sprint champions and record-breaking baseball home run hitters. The fall out from this scandal in 2008, and the resulting US grand Jury investigations, have had at least as much impact in sport as the East German doping programme or the Ben Johnson affair.

It will become clear in this book that we have only scratched the surface of possible artificial enhancements. The science, especially of genetics, has expanded quicker than the ‘drug cheats’ have been able to keep up. The number of performance enhancing drugs that have ever been used to date is a tiny fraction of the total possible compounds that we can conceive of producing. We know that ther is a lot we don’t know.

We know so little because we spend so little. In nearly all cases the limiting factor in our knowledge is lack of money. Despite what many may think, in global terms sport is poorly funded. The market for medical and recreational drugs dwarfs the market for those used for performance enhancement. Only where the requirements to compete at sport overlap with a medical need are dopers able to move quickly, piggybacking on new pharmaceutical discoveries to enhance performance.

There are clear parallels between drugs in sport and drugs in society. Both are here to stay. We ma not like them; we might rage against them; some politicians even think it worth fighting a war agains them. But it is a war that cannot be won. This does not mean there should be no efforts to limit drug use—giving up could be worse. But no one should think there will ever be a time when humans can b completely prevented from using chemistry to enhance their sports performance.

Whether active scientists, athletes, or armchair fans we should empower ourselves to enter the debate about drugs in sport informed by the latest scientific findings, rather than by the words of politicians or disgraced coaches. In this world of sporting drugs and cheats there is much talk and policy that is arbitrary and unscientific; it need not be so.

1

Introduction

> ‘If anyone competes as an athlete, he does not receive the victor’s crown unless he competes according to the rules’
> **(The Second Letter of St Paul to Timothy 2:5)**

What’s in a name?

Run, Swim, Throw, Cheat is a scientific exploration of the role of drugs in sport. Why do athletes tak them and risk their health? Do they work? And there are long-term implications for our views of spo in society. For what will a chemically-enhanced future sportsperson look like? Some of the answers t these questions lie in the social and political spheres. But even then they are influenced by the scienc And the science is moving forward rapidly.

What do we think of drugs and sport? This is not a question with a simple answer across all historical time and cultural groups. Many people’s views are coloured by a rather hopeful view of sport as an honest competition that must be played on a level playing field. Drug-takers must be cheats; rules are being broken. I sympathise with these views. Although perhaps I am seduced by my nationality. As Roland Renson says[1] ‘Modern sport originated in Great Britain as a cultural product o modernity, emphasizing equality and competition. Fair play was the moral creed of this new sporting ethos, created by nineteenth century upper and upper-middle class Englishmen’.

Sport has not completely abandoned this idealistic view. In the language of sporting chemicals there is a careful division in nomenclature between the accepted ‘ergogenic aids’ and the unacceptab performance-enhancing ‘drugs’. Yet the distinction between these two definitions is complex and variable. The authorities have been known on more than one occasion, notably with regards to stimulants, to transfer molecules back and forth between categories. One person’s ergogenic aid is another’s drug; things are not as black and white as a simple reading of Renson might suggest.

In our present historical times, drugs in sport have existed in the context of both national and individual competition. East Germany proclaimed the superiority of its political system by drug-induced gold medals; in the West capitalism led to more diverse, but not necessarily less effective, systems of delivering similar outcomes. For every communist East European Petra Schneider racing over ten seconds clear of British heroine Sharon Davies in Olympic 400 m swimming, there was a capitalist Canadian Ben Johnson, running a scarcely believable 9.79 s in the Seoul Olympics 100 m sprint. Growing up in Britain, and studying biochemistry in Canada, my youth was full of the pain of Sharon and the shame of Ben.

The phrase ‘drugs in sport’ comes with extensive emotional cultural baggage. When people think of drugs in society at large, their views are coloured by the roles played in medicine and recreation. A ‘drug’ is a powerful external agent. When prescribed by a doctor it can heal illness or induce painful side effects; when taken on the street it can leave you savaged, addicted and ruined for life. So we should not forget that the word ‘drug’ itself is evocative and we take that image into our views of the ~~effects in sport. Using the word *drug* gives the public an excuse to stigmatise something they find~~ unacceptable. But it also benefits the drug users. Appropriate labelling enhances the benefits of their performance aids via the powerful placebo effect—for who wouldn’t run faster with a magic custom *drug* in their body? Even Willy Voet, in his confessional book about doping in the Tour de France, admits that sometimes giving just a simple sugar solution had amazing results.[2] All he had to do was tell his cyclist it was a drug that ‘could be anything and everything’.

Names also matter. Pharmaceutical companies agonise over what to call a drug. They know that a good name will improve efficacy as well as marketability. Names are targeted to treatments; the sam compound (sildenafil) is called Revatio when used to treat arterial hypotension and Viagra when used for erectile dysfunction.

Given this backdrop, it is notable that the main agency testing for performance-enhancement, the World Anti-Doping Agency (WADA), never uses the word ‘drug’—instead preferring ‘doping’ and ‘doping offence’. However, in popular sporting culture there is no way to avoid this nomenclature, no the effect it has on the athlete’s environment. The link between society’s views of recreational drugs and its view of sport doping is clear—not least because many recreational drugs incur a doping offence, even when it is very unclear what sporting benefit they can provide.

A history lesson

There are many parallels between recreational and performance-enhancing drugs. Both have only recently become unacceptable. For although drug abuse in society tends to be considered a modern problem, it is really the negative response to drug use that is the new issue. Opium was the recreational drug of choice in the Ottoman Empire and in the New World coca was considered so innocuous that it featured in the original version of the most famous of soft drinks that bears its name Indeed the US government even took the Coca Cola Company to court, accusing it of not including enough coca in its product to justify use of the brand name and, even worse, replacing it with caffeine which was considered at the time to be a more dangerous drug. This led to the wonderfully entitled 1911 court case ‘The United States v. Forty Barrels and Twenty Kegs of Coca-Cola’.[3]

A similar lack of concern about chemical enhancement holds in the field of sporting endeavour. W can go as far back as the ancient Egyptians who allegedly used boiled hooves of asses to improve the performance. Indeed the possible benefits of different ergogenic aids seemed to be as hotly debated then as today. Charmis of Sparta swore that dried figs led him to Olympic gold in 668 BC, whereas on of the fathers of modern medicine, the second century Greek physician Claudius Galen, noted the positive benefits of eating herbs, mushrooms and testicles. Galen was the physician to the gladiators, the kind of ‘sport’ where you can’t get away with a bad day at the office and optimal preparation of body really matters.

Debates continued to rage about diets into the third century. In the view of Philistratos (AD 200) th Ancient Greeks ‘made war training for sport and sport training for war.’[4] But he bemoaned his generation of sportsmen who ‘spent too much time eating, drinking and fornicating instead of actuall training’ and who treated sports ‘more of a hobby than a way of life’. This was reflected in their poor choice of nutritional aids. Greek athletes of his generation ate white bread, poppy seeds, fish, and por while the ancient Spartan athletes trained on a meat-full diet of bulls, oxen, goats, and deer. [4] Perhap too much should not be made of the details of Philistratos’ complaints. After all he does sound all too much like a grumpy old man evoking the splendours of yesteryear. Indeed modern studies suggest th Galen’s gladiators ate a quite un-Spartan diet of barley and beans washed down with a vinegar/ash ‘sports’ drink.[5] And as for fornication, in AD 77 the famous Roman author Pliny the Elder suggested that sluggish athletes were actually revitalised by sex.[6]

Philistratos and others might have bemoaned the nature of the ergogenic aids used in their day, bu it is difficult to find any notion in the ancient world that using a particular compound or diet was unfair or should be banned. The debate, as far as we can judge, was about methods not morals. The view seemed to be that any way to obtain an edge was fine. Dietary supplements and extracts were ju another way to achieve this. The use of performance enhancing chemicals continued from the ancien to modern era unabated and unchallenged. In 1904 Thomas Hicks won the Olympic Marathon in St. Louis on a combination of strychnine injections laced with brandy. This didn't seem to concern the authorities, although maybe they were distracted by chasing the original winner, Fred Lorz, who was disqualified for covering eleven out of the twenty-six-mile race in a car.

In the inter-war years, German and American scientists and coaches were openly experimenting with a wide variety of performance-enhancing compounds, including cocaine, adrenal hormones and amphetamine. Britain was not immune. Arsenal football club happily handed out stimulant pep pills before a key 1925 cup match against their local rivals, West Ham United. They were told these pills would enable their players to 'put in shots that looked like leather thunderbolts'.[7] The West Ham keeper was untroubled: the match ended in a 0–0 draw.

Although the Arsenal players and manager were happy to discuss this drug use in a very matter-of fact manner in their biographies, at the time the football club did have some qualms about openly advertising their methods. No such false modesty accompanied rival football club Wolverhampton Wanderers a decade later in the 1930s. They even informed the media of their latest pharmaceutical tricks, publicising their use of extracts of monkey glands in the newspaper the *News of the World*. Although some people were concerned about potential health risks, there seems to be no great public outrage about 'cheating' and the use quickly caught on, with both FA cup finalists stoking up with th glands before the 1939 final.

However, the late 1930s did see the first signs of the sporting bodies beginning to act. The amateu International Olympic Committee banned the use of 'drugs or artificial stimulants of any kind' in 1938. As ever professional sport moved slower; there was speculation that a 1939 meeting of the Football League would address the increasing use of gland extracts but this came to nothing. More significant world events were about to intervene to disrupt sport. Yet World War II also had its pharmaceutical angle; there was extensive use of amphetamines by the armed forces of both sides.

In the 1940s amphetamine was in widespread use in society and not just for medical use. Society a large, whilst being warned off heroin and cannabis, was happily taking amphetamines as Benzedrine inhalers or in tablet form. People were using it to enhance mood, increase alertness and decrease the need for sleep. Amphetamine use in society was mirrored in literature. Whilst not surprisingly 'bennies' feature extensively in the novels of the beat generation guru Jack Kerouac, those of us who grew up on the James Bond movies will perhaps be surprised that the gadgets that aided him in his novels were as much biochemical as electronic. Forget a vodka martini 'shaken, not stirred'—in the book *Moonraker*, a benny slipped into his champagne enables Bond to stay alert for an all night card game. This doping scene was mysteriously missing from the movie. Not surprisingly sport mirrored society, with widespread use of drugs, mostly stimulants throughout the 1940s, '50s and '60s.

As in society, so in sport, drug use was increasingly being considered negatively by the 1960s. Thi led to a drugs crisis with the governing powers making serious attempts to ban the 'evil' of drugs in sport and society. In the USA, Benzedrine inhalers were made illegal in 1965, with the hallucinogen LSD (lysergic acid diethylamide**)** following in 1968. In sport, drug testing was finally introduced in 1965 to back up bans on stimulant use. There was open resistance to this clampdown by the individuals concerned. At the same time as Californian hippies were protesting the criminalisation of

LSD, Olympic cyclists were boycotting amphetamine drug tests.

~~Yet by the 1970s drug use in both sport and society had become publicly unacceptable.~~ In 1971, President Nixon declared, ‘America’s Public Enemy No. 1 is drug abuse’. In the sporting world this period coincided with the increasing use of anabolic steroids, rather than amphetamines as the drug c choice to enhance performance. Unlike amphetamines, steroids had never been in general use by the public. There was no positive narrative that athletes could access to gain public approval. There woul be no steroid equivalent of Tommy Simpson, the amphetamine-fuelled British cyclist who has a hero’s memorial to his 1967 death on the slopes of Mont Ventoux in France. Today’s narrative between drug ‘cheats’ and anti-drug ‘heroes’ has became firmly established in both the sporting and recreational arenas.

Pharmaceutical developments

The parallels between drugs used in sport and society relate to more than just cultural associations. They both share a common source for the products they use. The pharmaceutical industry has been th major driving force for all drug use in society. Indeed most recreational drugs were accidental by-products of attempts to create medically useful products. Heroin and cocaine were originally used as very effective pain killers, LSD was a by-product of attempts to make new central nervous stimulant and MDMA (3,4-Methylenedioxymethamphetamine, widely known as ‘ecstasy’) was a failed attemp to produce a product to prevent abnormal bleeding. Likewise with drugs used in sport: anabolic steroids were used to treat muscle wasting, erythropoietin (EPO) to treat anaemia, and human growth hormone for childhood growth deficiencies.

Not content with using existing products, people eventually began bypassing the medical market t develop new ‘designer’ drugs solely for recreational use. This began in the 1960s and 1970s with the development of minor chemical modifications to illegal hallucinogens such as LSD and PCP (Phencyclidine, also known as ‘angel dust’) in order to avoid criminal prosecution. It took sport long to catch up, but in the late 1990s US amateur chemist Patrick Arnold started to synthesise and distribute drugs that had never been used in patients. These included norbolethone—a steroid abandoned by Wyeth Pharmaceuticals and never marketed for human use—and tetrahydrogestrinone (THG), the world’s first completely novel designer anabolic steroid for sporting use. As with the manufacturer of designer LSDs, the main rationale was not to produce a more effective molecule but to avoid punishment by the authorities. In the case of the recreational designer drugs the intention wa to design a molecule that even if it were discovered would not be covered by legislation. In the case o sporting designer drugs, the idea was to avoid detection in the first place by being immune to doping controls—hence the nickname of THG as ‘the clear’.

For these designer drugs, the authorities were ultimately victorious. Tim Scully and Nicholas Sanc were prosecuted for making the acetyl amide of LSD, known as ALD-52. They were convicted on the basis that, although ALD-52 itself was not illegal, they had to have possessed illegal LSD as a startin material for its chemical synthesis. Patrick Arnold had his come-uppance when a disgruntled co-conspirator, coach Trevor Graham, anonymously mailed a syringe of THG to the authorities. A test was developed and caught a number of athletes, most notably the British sprinter Dwain Chambers. This led to the BALCO (Bay Area Laboratory Co-operative) scandal and the resulting US Grand Jury subpoenas of a number of famous athletes.

What about the future? Can the dopers break free of the intellectual shackles of the pharmaceutica industry and develop genuinely new biochemicals that surpass the current limits of human performance? Will novel molecules be developed in private laboratories run by rich mad scientists, resulting in a *Jurassic Park* future of genetically engineered and chemically super-enhanced sportspeople? It is easy to get carried away with these questions. But in many cases the fantasy is without foundation. The internet has indeed brought a community together that are happy to sample any research chemical they can get their hands on for possible psychoactive or performance-enhancin effects. However, the development of genuinely new molecules is still likely to require the budgets and intellectual effort that only the big pharmaceutical companies, or the worldwide scientific community can muster.

Even so-called new recreational designer drugs such as desoxypipradrol, methylenedioxypyrovalerone (MDPV) and methylmethaqualone (MMQ) are based on established drugs, published patents or are obvious derivatives of these. And if this is so for recreational drugs, where serious profits exist, it is doubly true for the sports performance market. The fame may be larg in sports, but the profits for any new compound—at least compared to the pharmaceutical and recreational drugs market—are likely to be relatively small.

What this means is that knowledge of the science of the future is already in our hands. The future ideas in performance-enhancing drugs are unlikely to come from secret laboratories funded by rich benefactors intent on creating a new species of elite athlete. The ideas are out there already. We can look at the scientific evidence in human and animal studies to see what works now and what could work in the future. We can confidently explore the range of biochemicals that have the ability to enhance human performance by the traditional means of reading the scientific literature and applying our knowledge of human performance. We already have access to the knowledge to understand what has been done, what is being done and what will be done to improve sporting performance. That indeed is the purpose of this book.

How do we know that drugs work?

To answer this question we will need to understand the molecular mechanisms underpinning the performance-enhancing chemicals currently on the market. What are these chemicals? Athletes are, not surprisingly, secretive about their doping regimes. Can we ever be sure exactly what an athlete is taking? We do have some useful pointers. Detailed notes from the East German doping regime of the 1970s are now available and the recent US court cases over the BALCO scandal (vide Dwain Chambers) give real insight into the doping methods and rationales used by coaches. Doping was not restricted to simple anabolic steroids in East Germany [A] or the UK [B]

> [A] ‘In this drug administration program > 2000 athletes preparing for international competitions were treated each year. In addition, numerous “cadre B and C” and junior athletes, including minors, were also treated with androgenic hormones and with substances such as human chorionic gonadotropin (hCG) and clomiphen, which stimulate endogenous testosterone synthesis’.[8]

> [B] ‘Dear Dwain,
>
> Per your request, this letter is to confirm I am willing to assist you in providing UK Sport and others with information that will help them to improve the effectiveness of their anti-doping programs. The specific details regarding how you were able to circumvent the British and IAAF anti-doping tests for an extended period of time are provided below. Your performance enhancing drug program included the following seven prohibited substances: THG, testosterone/epitestosterone cream, EPO (Procrit), HGH (Serostim), insulin (Humalog), modafinil (Provigil) and liothryonine, which is a synthetic form of the T3 thyroid hormone (Cytomel).

Yours sincerely,

Victor Conte'[9]

So we do have some insight into the kind of methods coaches are actually using in elite athletes. This is a very useful starting point. But how do we know something is performance enhancing? This is not as simple a question as might first appear. Just as with medical drugs, so in the world of sports doping, early promise in the laboratory is rarely matched by an equivalent effect in the field. In both cases part of the problem is the nature of the subject. In the case of medicine a drug is trialled on healthy animal models and people before being tested on an abnormal and heterogeneous subject group—unhealthy patients. The multitude of interacting pathologies (and even simple old age) can reduce the effect when the drug is finally marketed.

The same effect occurs in sport, but for almost completely the opposite reason. The test subjects are not healthy enough. Laboratory tests are almost never on elite athletes, as volunteering for a legitimate study would disqualify them from competition. Instead normal healthy athletes are used. However, elite athletes are abnormal. We are not even sure that the biochemical mechanisms underpinning a performance enhancement in the average athlete are exactly the same as in the elite athlete. It is entirely possible that by a combination of genetic predisposition and extensive training, the elite athlete will have already acquired the improved performance a drug or ergogenic aid purports to yield. Even though the difference between winning and losing is often measured in fractions of a per cent, laboratory success does not always translate to performance benefit. With the possible exception of the East German STASI (Ministry for State Security) documents, we do not have scientific tests on elite athletes following the administration of potentially performance-enhancing drugs.

Some useful performance tests of individual compounds have taken place in controlled laboratory settings. Yet in the real world the presence of other drugs and nutritional aids can interfere with the drug being tested. Athletes are notoriously secretive even about their legal training methods and ergogenic aids, let alone the doping agents they are using. They use drug regimes that are impossible to reproduce ethically in laboratory or animal studies. For example to study scientifically the cocktail of drugs Dwain Chambers used we would need to dope a population of fit athletes, remove one compound at a time from the list and explore the resulting performance effect. This is far too complex and time consuming, even if it were ethical. Patients are frequently excluded from testing new treatments in clinical trials if they are on additional medication as it can confuse the analysis of the data. Any patient with the drug combination Dwain Chambers was using would not have the remotest chance of being selected to be a subject for a scientific study.

For all these reasons a ten per cent increase in performance in laboratory trials on 'normal' subjects never results in a ten per cent increase in elite performance in a sports event. Nevertheless we are stuck with this subject group. There is a fine quotation about the scientific method in Robert Pirsig's philosophy book *Zen and the Art of Motorcycle Maintenance*.

> When you've hit a really tough one, tried everything, racked your brain and nothing works, and you know that this time Nature has really decided to be difficult, you say, 'Okay, Nature, that's the end of the nice guy,' and you crank up the formal scientific method. There's no fault isolation problem in motorcycle maintenance that can stand up to it.[10]

When testing the efficacy of any treatment in humans, whether medical or sporting, the randomised double-blind placebo-controlled trial is the equivalent of Pirsig's 'formal scientific method'. Uncreative, boring and tedious to implement, but no one can argue with the results. However, unlike other popular science books that dissect the effect of pills and medical treatments, you will now be aware that we cannot employ this tool to full effect when studying aids to top performance in human athletes. The truth is out there, but we will need to use our detection skills and scientific intuition as much as brute force clinical trials.

Can evolution be beaten?

What are the limits of human performance? What are the areas where ergogenic aids and drugs really could help? In some ways these are questions about evolution. If human evolution has optimised performance in certain activities, it may be more difficult to enhance them artificially. But if a particular sport requires skills that do not relate to something that we have evolved to do, there may well be scope for massive pharmaceutical improvement. This argument can be likened to a comparison of the benefits of sunscreen. Someone evolved in a hot, bright climate with suitably dark skin has little need of chemical enhancement to survive in the midday sun. On the other hand someon with light skin will burn. Only in the latter case will the chemical enhancement (sunblock) be of benefit.

So what kind of physical performance have we as humans evolved to optimise? As ever when looking into the evolutionary past there is uncertainty. It has been suggested we are poor runners compared with many other mammals, as the evolution of our brains enabled us to use tools rather tha our bodies to hunt. We have lost our tails, an essential component of fast runners such as kangaroos and cheetahs. When it comes to sprinting, we won’t win many awards in the animal kingdom. So maybe running is a largely irrelevant adaptation, piggy-backing on our need to walk upright? If natural selection has not acted primarily on speed or endurance running there could be a lot of capacity to improve on evolution. Could drugs act where evolution hasn’t?

At least when it comes to endurance running, recent anatomical and anthropological studies sugge that this argument may not be strong.[11] We have several adaptations for running; these include long, springy legs and big, muscular buttocks that, at least in part, can replace our lack of tails. Our relatively long neck allows our shoulders to twist independently of our head as we gaze forward. But more importantly we lack hair, sweat a lot and have a very thin skin with blood vessels close to the surface. All of these adaptations maximise heat transfer from the body to the environment. Why does this matter? Due to the massive increase in oxygen consumption, animals can generate as much as si times the heat when running compared with lying down. This puts a major break on long distance running—you can literally burn yourself out if you don’t stop. In one, possibly apocryphal experimen at Harvard, biologists put a rectal thermometer in a cheetah and found that once it hit 105°F (41°C) i stopped, even though it was running well below its normal fastest speed. It seems this is less of a problem for humans. We have evolved, at least in part, for slow long running. This enables us to trac our prey by a technique called ‘persistent hunting’. This strategy involves targeting one animal and tracking it exclusively, usually starting in the hottest part of the day. As long as the same animal is hunted we will generally win our meal—even if it has to take over a day.

While not exactly having the tracking skills of today’s persistent hunters—the Bushmen of the Kalahari or the Tarahumara of northern Mexico—I have on occasions revelled in my superiority as a hunter. Admittedly my prey was just my garden rabbit who was avoiding being returned to her cage. After wasting many hot summer days unable to outrun her, I changed strategy to walking after her slowly and persistently. Eventually, after about ten minutes brisk walking, I could easily catch my exhausted prey. The same skills can be seen when humans race animals competitively. When running for a whole day humans have the capacity to outperform other species that are far faster over shorter distances such as dogs and horses. Twenty miles seems to be the tipping distance; the village of

Llanwrtyd Wells in Wales hosts the annual man versus horse marathon. Usually, but not always, the horse wins. The only time men won both first and second place was on a very hot day, perhaps provin that as a species we run better in the heat.

How about strength? Are we humans optimised for power events? Again the evolutionary history i not straightforward, but most commentators suggest the evolutionary path that led to *Homo sapiens* involved a decrease in power capacity. Certainly all the other current great apes are much more powerful and muscular than the average human. And while it is not easy to determine power from skeletons alone, rival species like Neanderthal man certainly seem more likely to have been stronger than the co-existing modern humans. Gary Sawyer, an anthropologist at the American Natural Histor Museum in New York[12], says, ‘They had very strong hands. If you shook hands with one, he would turn your hand to pulp.’ Theories of the extinction of Neanderthal man 27,000 years ago have include suggestions of direct attacks by our ancestors. Yet no one is suggesting the success of *Homo sapiens* was due to raw physical attributes.

Conclusions about modern attributes of man based on evolutionary arguments always have the danger of sounding a bit like a ‘Just So’ story. But at the risk of making a dangerous prediction, I wil venture to say that my reading of the evolutionary runes is this: if there is any sporting endeavour where drugs and ergogenic aids are *least* likely to have an impact it is in the field of the ultramarathon. ‘Slow and steady’ has already won the evolutionary race.

The case for sex

There is one glaring exception to all these ideas. Evolution has not acted equally on men and women. And this is most clear when it comes to the allocation of genes that control power and strength. The reason for this is not as obvious as it might seem. It is unlikely to be a product of differential hunting requirements. Indeed in many mammals it is the females that do the hunting. There seems no reason, apart from cultural, why a woman could not hunt as effectively as a man, whether over a short period or persistently for two days—and of course great apes that only hunt vegetables (gorillas and orangutans) still have males that are considerably more powerful than females. Instead the selection for strength is most likely a product of males fighting other males in competition for mates.

The evolution of human sexual dimorphism (the differences between the sexes) is highly contentious. Witness the controversy surrounding E.O. Wilson’s book launching the subject of Sociobiology and the resultant heated debates about the evolutionary underpinning of human behaviour.[13] Perhaps this is not surprising as the areas under discussion include sexual preference, sexual behaviour and intelligence. With regards to less contentious issues such as physical strength you might think there was more consensus. But surprising traps exist for the unwary even in this area The earliest bipedal hominid was the extinct species *Australopithecus*. You would think that there would be an accepted wisdom about basic structural dimorphism (at least with regards to the size of the male and female skeleton). But a debate still rages over claims that our earliest two-legged ancestor had males as much as fifty per cent larger than females.

Whatever the exact details, it seems likely that males and female hominids have indeed become similar in size with the passage of evolutionary time. But they are not there yet. Except in those rare events where strength is not a factor at all, we still have distinct male and female sporting categories What this means is that evolution has allowed a large scope for improvement to any female who can increase their male physical characteristics.

Victor Conte founded the infamous Bay Area Laboratory Co-Operative (BALCO) that was accuse by the US Anti Doping Agency of supplying anabolic steroids to a wide variety of athletes including Dwain Chambers; in 2005 Conte pleaded guilty in the US court to conspiracy to distribute steroids.

This is what Conte said about doping female athletes,[14] ‘Steroids can help a female sprinter to lower her 100 m time by about four-tenths of a second or four metres faster. The effects of steroids upon male 100 m sprinters are about two-tenths of a second or two metres faster.’

Whilst not necessarily agreeing with this statement quantitatively, qualitatively it is sound. Femal world and Olympic records set prior to random drug testing have been much harder to break. For example, whilst there is a steady progression in the male Olympic athletic records, there are as many female Olympic records still standing that were set prior to 1990 as those that were set in the last decade (see Figure 3). It is hard not to argue with the implication that the steroid doping that was widespread in the 1980s has had a more dramatic effect in female sport than male sport.

But the male/female issue has other implications. There are methods other than steroids to close the gulf in performance that exists between male and female sports. The simplest is by direct subterfuge. The 1938 European Champion high jumper, Dora Ratgen, is perhaps the most famous example. Ratgen’s case featured in the film *Berlin* 36. In it she was unmasked as a transvestite member of the Hitler Youth picked for Hitler’s 1936 Berlin Olympics in place of the genuinely fema Jewish athlete Gretel Bergmann. However, on closer inspection[15] this case is more complex. There is no evidence that there was a Nazi conspiracy to infiltrate a transvestite into the team. In fact Dora Ratgen had somewhat ambiguous genitalia at birth, was registered as a woman and brought up as a girl. The Nazis were unaware that she was a man. Given the nature of the times it is unlikely the German authorities required such an elaborate subterfuge to discriminate against a Jewish athlete anyway. Upon being discovered in 1938 and being shown to indeed be genetically and physiologicall male, Dora quit sport and changed her name to Heinrich.

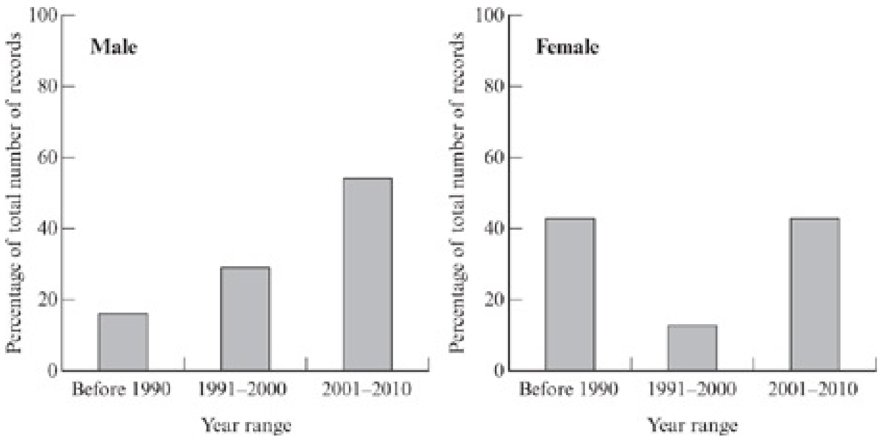

Figure 3 A comparison of male and female Olympic records in athletics

The graphs indicate the year range in which a current Olympic record (as of 2008) was set.

Such direct subterfuge was very rare in the past and is probably nonexistent now. Yet there are more subtle grey areas between what constitutes a male and female athlete. Suspicion about the gender of supposedly female athletes led the International Olympic Committee to introduce gender tests at the 1968 Olympics. These degrading and simple physical examinations were later replaced with a scientific chromosome test for the presence of the male Y chromosome. But even this is not foolproof. At the 1996 Olympics in Atlanta, 8 of 3,387 female athletes were found to possess a Y chromosome.[16]

How could a person have female characteristics, despite the presence of a Y chromosome? In seve of the cases, the cause was Androgen Insensitivity Syndrome (AIS), a condition where the body does not respond to the male hormone testosterone; in one case the problem was a deficiency in the enzym that activates testosterone. The lack of response to testosterone during foetal development in these conditions generally results in external genitalia that are mostly female. So although these women may have had the same testosterone levels as men, it was assumed that this testosterone could not lea to a ~~performance enhancement and the athletes were allowed to compete. However, whilst the~~ prevalence of AIS in the general population is 0.002 per cent, in women competing in the Olympic Games it is 0.2 per cent. This 100-fold increase, suggests the possibility of some performance enhancement due to this syndrome.

Most people with AIS syndrome have XY sex chromosomes, but still consider themselves female The International Olympic Committee now think the same—they abandoned compulsory gender testing after Atlanta. But they retained the right to test for gender if necessary and the suspicion existed that if a genuine world-beater emerged with ambiguous sexuality the story might be differen And this was precisely what happened with the recent cases of Santhi Soundarajan and Castor Semenya. Soundarajan failed a gender test at the Asian games in 2006 after winning the silver medal in the 800 m race. Castor Semenya was a convincing winner in the Berlin 2009 World Championship in the same event. She was subsequently withdrawn from international competition pending an investigation. Eleven months later the International Association of Athletics Federation cleared her t compete. It has been suggested that as part of this process she is required to undertake therapy to reduce her testosterone levels.[17]

Is it all in our genes?

The clear male/female differences in sport performance do raise interesting questions about athletes who are genetically rather than pharmacologically enhanced. If a genetic mutation that makes a female athlete more ‘male’ makes that competitor ineligible, what about another that makes a male athlete run faster or jump higher? After all, elite athletes are all genetic anomalies—it is just a question of how extreme the anomaly. Will there soon be DNA testing to accompany drug testing?

Sport has so far avoided this problem by assuming that performance is multifactorial. To be an elite athlete, it is wise to choose the right parents, but no one has previously thought that this is due t inheritance of a single gene modification. Unlike in TV shows, you cannot inherit superhero abilities Yet recent research has raised serious doubts about this cosy hypothesis. In many domestic and laboratory animals it is indeed true that a single gene can make a dramatic difference in strength and endurance. And there is a precedent in elite sport.

Eero Mantyranta, a Finnish cross-country skier who won gold medals in the 1960 and 1964 Winte Olympics was found to have abnormally high levels of the protein haemoglobin in his red blood cells High haemoglobin levels allow athletes to carry more oxygen and are a benefit in endurance sport. Mantyranta, like all his family who were tested,[18] achieved their high haemoglobin levels by having genetic mutation in the protein in their body that responded to the hormone erythropoetin (EPO). At normal levels of EPO the effect on their body was as if they had much higher levels. A stronger EPO effect means more haemoglobin and therefore more oxygen to their cells. EPO is top of the list of genuinely performance-enhancing chemicals; yet here is someone who through an accident of birth behaves exactly as if he was doping with EPO. Is this fair? How is it different from the case of Santh Soundarajan and Castor Semenya? The more we know about the genetic make-up of elite athletes the harder our decisions about what is right and proper in sport will appear. In ten years’ time full geneti profiling may be commonplace. We may also have knowledge of some rather specific genetic adaptations that improve sporting performance. What do we do to ensure fairness in competition in this case? Doping control will not be enough. The Paralympics currently has a wide range of classes that reflect the differing physical abilities of athletes. Will the same be true of the rest of the Olympics? Will there be different classes dependent on different genetic sequences in key molecules in the body? I once would have thought this a fantasy. Now I am not so sure.

I will explore the intricacies and complexity of artificial genetic manipulation in the final chapter of this book. But for now there is enough to explore in the kind of drugs used in the two races described in the Prologue. Sporting achievement requires power, endurance and the ability to compet beyond the pain barrier. The unholy trinity of anabolic steroids, EPO and stimulants can impact in these areas. But before we study these drugs there is a need to explore in more detail the factors that can limit athletic performance.

sample content of Run, Swim, Throw, Cheat: The science behind drugs in sport