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From Fixed Capacities to Performance-Enhancement: The Paradigm Shift in the Science of 'Training' and the Use of Performance-Enhancing Substances

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The use of performance-enhancing substances fundamentally rests on a particular, historically situated, ontology of human performance. By analysing 'training' in the nineteenth and twentieth centuries, we examine the powerfully influential ontology that frames substance use today. Rooted in the first law of thermodynamics, an ontology of fixed human capacities dominated until the mid-twentieth century. Training entailed 'drill' to refine technique, coordination and precision. Although physiologists showed exercise increased strength and endurance, it was not until the cold war period that the paradigm shift to 'performance capacities' occurred. Track, weight lifting and cycling provide examples of how and why this happened.

'Would you still take the drug?'

In *Death in the locker room*, Bob Goldman cited Dr Gabe Mirkin's poll of more than a hundred top runners whom he asked 'If I could give you a pill

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that would make you an Olympic champion – and also kill you in a year – would you take it?' More than half said yes. Goldman asked 198 world-class athletes a similar question: 'If I had a magic drug that was so fantastic that if you took it once you would win every competition you would enter, from the Olympic decathlon to Mr Universe, for the next five years, but it had one minor drawback – it would kill you five years after you took it – would you still take the drug?' [1] Again, more than half said yes.

There are four points to note about those polls. First, the data are largely meaningless, especially Goldman's, because his claim about the magic drug was too unreal to take seriously. In Mirkin's case, if athletes were offered pills to take as the question was asked and half did, then the data might mean something. But those are minor points.

More important is Goldman's rhetorical strategy. Discounting his extreme scenario – 'it can be argued that it is only because the athletes knew there is no such magic medicine that they indicated their willingness to commit Olympic *hara-kiri*', and faced with a 'real-world magic medicine, they would have second thoughts' – Goldman presents one that appears, in contrast, very creditable. 'Perhaps this argument [that faced with a real medicine the athletes would have second thoughts] is correct', Goldman wrote, 'but the evidence suggests otherwise': 'The evidence suggests that athletes will take anything or do anything to their bodies to win, with no assurance of winning, and in apparent disregard for their lives beyond Olympia, or sometimes beyond the next major competition.' [2] Dismissing the obviously fantastic to make a different, more important thesis appear completely credible is an effective strategy.

Goldman wrote *Death in the locker room* to argue that steroids and other performance-enhancing substances kill athletes. His key claim is that even without any guarantees of success, athletes will do anything to win. Well before he presents any real, systematic evidence, Goldman's rhetorical strategy seems to prove his central thesis. With the second claim established, the first one becomes plausible and that question – or one like it – is all one has to refer to when demonstrating the power of anabolic steroids and the hold they have over athletes. [3]

Of greater importance, Goldman's 'study' is referred to time and again in discussions about performance-enhancing substances. Though merely a rhetorical device, a paraphrase of Goldman's question is frequently used to demonstrate that athletes will do anything to win. [4] As rhetoric, it is effective; as analysis, it is a serious impediment to the debate about the use of performance-enhancing substances in sport.

The most serious outcome of Goldman strategy is how it shapes the public's, sport policy makers' and journalists' understanding of why and

how athletes use performance-enhancing substances. 'Would you still take the drug?' indicates that performance-enhancing substances are 'magic bullets' that athletes simply take and results – both positive and ominous – follow without fail. Substance use is completely removed from the social and historical context within which it occurs.

On the social side, the Goldman claim ignores the close relationship between athletes and coaches. In fact, it implies a manipulative one where coaches, focused only on results, offer athletes substances they know little about except that they are effective and dangerous. The claim brackets the totality of athletes' life experiences and their sophisticated knowledge about every aspect of their sport as they progress through its increasingly demanding and competitive levels. Athletes and coaches do not naïvely use performance-enhancing substances and practices as they strive to be the world's best.

Important as the social context is, it rests on a more fundamental foundation – the particular, historically situated understanding of the ontology of human performance. This primary foundation is the focus of this paper – the core, deeply seated, powerfully influential ontology that frames athletes' and coaches' decisions about the use of performance-enhancing substances in the modern era.

Simply knowing that there is an important historical context underlying the use of performance-enhancing substances is not enough to dispel the Goldman claim and others like it. A more profound analysis is required if athletes, coaches, and policy-makers are to fully address the use of various performance-enhancing substances and practices in modern sport. To that end, this paper focuses on the fundamentally important paradigm shift that took place during the middle part of the twentieth century regarding the notion of 'training' and the ontology of human performance. Based on a different ontological conception of human performance, the paradigm shift we discuss changed how coaches and athletes thought about 'training' as well as the way they understood performance and performance-enhancement. Those changes completely altered athletes' and coaches' approach to performance-enhancing substances (and other practices). Any meaningful debate about performance-enhancing substances must address the ontological bases for the science that produces them and the practices which lead to their use.

The development of 'training' in sport

The application of science to progressive training methods in sport is a recent development. While scientists in the nineteenth and early twentieth

centuries studied athletes, they did not do so to enhance or boost performance capacity. [5] Scientific discourse was contoured by the law of the conservation of energy (the first law of thermodynamics). Moreover, in accordance with the conception of science at that time and the concomitant belief that scientific laws applied universally, the laws of one area were applied to others; this was especially true of the laws of basic physics which were seen as among the purest of scientific discoveries. As a result, the first law of thermodynamics was applied to the scientific understanding of many realms, including how the human body operated.

In the 1830s and 1840s several European researchers – most notably Julius Robert von Mayer, James Prescott Joule and Hermann von Helmholtz – worked simultaneously on theoretical aspects of the doctrine. [6] The first law states that energy can be transferred from one system to another but it cannot be created or destroyed. The total amount of energy in the universe is constant. Einstein's theory of relativity – $E = MC^2$ – describes the relationship between energy and matter precisely and indicates that energy (E) is equal to matter (M) times the square of a constant (C). The equation demonstrates that energy and matter are interchangeable and, if the quantity of matter in the universe is constant then the quantity of energy is also fixed. [7]

While the conservation of energy applied directly to non-organic matter was instrumental in the development of machines, its proponents applied it to the human organism, comparing its biological and physiological functions to non-living systems such as mechanical engines. [8] 'As the power to work is without question the most important of the products of animal life', Mayer wrote in the 1850s, 'the mechanical equivalent of heat is in the very nature of things destined to be the foundation for the edifice of a scientific physiology'. [9] So while the doctrine's widespread influence included physics and the understanding of mechanical systems, it grew to encompass the study of living organisms, including an emerging body of work in human physiology. [10] The doctrine was extended to the understanding of human activity in social and institutional life, including physical education settings. [11] As a result, scientific studies of the human body in motion were part of a general scientific world view premised on the first law of thermodynamics.

The term 'training' existed in the late nineteenth and early twentieth centuries and coaches and athletes approached it within the premises of the first law. Training was synonymous with 'drill' – the repetition of skills to refine technique, improve coordination, and enhance precision and execution. Training was not designed to systematically increase

physical power, speed, endurance, and agility through specific, targeted programmes. [12] The scientific community and the sports world alike believed those attributes were fixed and, like a well-oiled machine, could only improve through greater precision and coordination. Thus even though the legend of six-time Olympic champion Milo of Crotona was known, the sociocultural conditions conducive to the application of modern training's basic principles (working against progressive resistance, over short intervals, for a long period of time) did not exist before the Second World War. [13]

While Pierre de Coubertin began to launch his modern Olympic project, athletic training manuals indicated that the principles of training 'differ but slightly from those of judicious living'. Both 'require the same close study and proper interpretation of the laws of health, and such an application of them as will produce temperate habits and a high degree of mental and bodily vigour'. [14] In 1889, Montague Shearman's *Athletics and football* stated that 'there is no reason why an athlete who desires to get fit should lead other than a natural life'. [15]

At the end of the nineteenth century, research observations emerged that would eventually challenge the 'fixed capacity' approach to the human body and lead to a new ontological conception of how the human functioned and performed. Working with cadavers, C. Hirsch (1899) noted a direct relationship between body musculature and heart size. Three years later Schieffer, and then H. Dietlen and F. Moritz (1908), noted that habitual cyclists had larger hearts than occasional and non-cyclists. [16] In 1905, W. Roux reported in *The mechanics of development* that increases in muscle size, strength and endurance were an effect of chronic exertion. This led to his theory of 'hypertrophy through activity' and 'atrophy through inactivity'. [17]

Although these early studies identified changes in the human body due to exercise, they were insufficient to cause a paradigm shift in physiology away from the first law of thermodynamics and were certainly too obscure to have any impact upon training practices in sport. Coaches and athletes were preoccupied with 'tapping the hereditary potential of the human or animal organism rather than artificially manipulating the organism itself'. [18] In the sport literature of the period, attention centred on the biologically endowed, natural-born runner, jumper or thrower and entire sections of books were dedicated to the suitability and significance of particular body types for specific athletic events.

Based on the law of the conservation of energy, training followed the 'natural method'. Actively advocated by France's Georges Hébert, the technique required athletes to get fully in touch with their natural

movements through drill and practice while emphasizing a continuous pace and eliminating unnecessary movements. While 'natural' in optimizing the natural talents of a given runner, the emphasis on pace, economy of movement and the use of clock time reflected something very unnatural, but the contradiction is only an apparent one. The 'natural method' was completely consistent with the first law of thermodynamics – a natural law. In addition, because the first law was a scientific law and applied to all instances of movement, Hébert's technique used the same principles that Frank and Lillian Gilbreth employed in their famous 'time and motion studies' in the workplace during that period as well as Fredrick Winslow Taylor's principles of scientific management. [19] Clock time, pace and efficiency of movements simply maximized natural capacities.

Taylor's principles maximized workers' output by reducing their movements to individual components and then optimizing the execution of each component. [20] Performance improved through increased precision and better technique – not increased performance capacity. Similarly, time and motion studies, whether in the workplace or on the track, optimized a given work capacity; they did not try to expand it by developing an untapped 'potential' capacity. Track and field coaches and industrial managers were working from the same set of assumptions about human performance and sought increased efficiencies rather than expanded capacities.

Finnish distance runner Hannes Kolehmainen was among the earliest beneficiaries of Hébert's technique. Kolehmainen trained at a specific tempo to determine the best running speed for his particular physique and style. At the 1912 Olympic Games, he won three gold medals including a victory over world record holder Jean Bouin in the 5,000 metres. Kolehmainen, followed by Paavo Nurmi and Ville Ritola, began the era of the 'Flying Finns'. Focusing on the style that best fit their physiques, positioning on the track, and emphasizing a continuous speed, Ritola and Nurmi, who ran with a stopwatch in his hand, dominated distance events throughout the 1920s. [21] Industrial efficiency – the conservation of energy – was the basic paradigm in athletic training in the early twentieth century.

Towards a paradigm shift in understanding human performance

While physicists, physiologists and coaches worked within the paradigm established by the law of the conservation of energy, anatomists, physiologists and laboratory researchers in other disciplines began to

undermine the paradigm with respect to human performance. During the inter-war period, European researchers began to build a scientific body of knowledge concerning human physiology which inevitably recorded observations related to exercise, human anatomy and physiology. Britain's Nobel Prize-winning physiologist Archibald Hill – 'a giant in the field of exercise physiology' – probably had a more profound impact than usually recognized. [22] Hill's demanding experiments in muscle fatigue, lactic acid formation and oxygen debt required subjects who could push themselves to the extreme. As a result, Hill used athletes in his research because they could tolerate his demanding experiments. [23] Two results emerged. First, the results suggested that the conservation of energy thesis, as it was understood in connection with physiology, was suspect; and second, one could not miss the potential application of Hill's research in muscle physiology to sport. Both of these contributed to the use of a newly developing paradigm in physiology and an emergent sport science.

In a similar manner, research into questions of basic physiology led scientists such as S. Hoogerwert, W.W. Siebert, L. Pikhala, Arthur Steinhaus, A. Vannotti, H. Pfister, T. Petrén, T. Sjöstrand and B. Sylvén to develop an experimentally based body of knowledge concerning physiological responses to exercise which was progressively linked more and more closely to athletic performance. [24] For example, in 1930 Pikhala noted that athletic success required different physical 'properties' – physical power, strength and speed – and he argued that they could be developed during training if there was a variation between activity and rest and a focus on intensity in practice sessions rather than simply just volume, and if work was narrowed to specific goals. In the inter-war period, Pikhala had articulated the essential components of progressive resistance training for athletic development. [25]

E.H. Christensen's work complemented Pikhala's as he found that regular training with a standard workload resulted in lowering the heart rate required to work at a fixed load. Further training, however, did not modify the response unless the load was increased in subsequent training sessions. When that was done, the original workload could be performed at an even lower heart rate than before. Christensen also established that physiological adaptation took place at a given load and to gain further improvements one had to increase the training intensity. [26]

In North America, leading-edge research in human performance was centred in the Harvard Fatigue Laboratory, which was established in 1927 and operated until shortly after the Second World War. Elton Mayo, one of the leaders in the 'human factors' direction of the Harvard Business School, was a co-founder of the laboratory with Lawrence (L.J.)

Henderson. The relationship between the laboratory and sport is interesting because the lab's 'human factors' approach to industrial relations stemmed directly from the Gilbreths' time and motion studies and Taylor's principles of scientific management. As noted earlier, time and motion studies and scientific management had begun to exert an indirect influence on athletic training in the 1920s. [27] Archibald Hill was also influential in the development of the laboratory; his studies inspired many of the scientists who would later go on to found the lab. [28]

The Fatigue Lab's collaborative research programme involved physiologists, biochemists, psychologists, biologists, physicians, sociologists and anthropologists. The collaborative approach allowed investigators to study the effects and interrelation of the human body's many systems. Most important, research centred on 'man's adaptation to his environment . . . not only his normal, everyday and working environments, but his adaptation to unusual stresses, such as athletic competition, exposure to strange environments and war'. [29] The Fatigue Lab focused on the physiochemical properties and behaviour of blood – at rest, work and altitude – and pioneered many aspects of exercise physiology and the study of physiological responses to altitude. In studies of fitness level, for example, the laboratory reached the same conclusions as Christensen regarding fitness, workload, and the improvement of maximum oxygen carrying capacity (or $VO_{2\ MAX}$). [30] The laboratory's study of lactic acid and exercise and the mechanisms and importance for actively removing it from the muscle were decades ahead of their application in athletic training. [31]

The inclusion of athletes in the lab's protocols was completely fortuitous. Although general fitness was of interest (the lab developed the well-known Harvard Step Test as a simple, inexpensive and efficient means of assessing general fitness), much of the laboratory's exploratory research was conducted on the lab workers themselves, and a number of them happened to be athletes of various levels and abilities. As a result, the discovery of differences among normal, trained and well-trained subjects occurred by chance rather than design. Nevertheless, despite the differences they discovered and the laboratory's particular interest in fitness, none of the research was directed towards enhancing athletic performance, even though the discoveries made in the areas of blood chemistry in exercise, aerobic and anaerobic work capacity, diet and physiological adaptation to physical work at altitude would all be used to enhance world-class athletic performance once applied sports physiologists had embraced the mid-twentieth century paradigm shift in human performance. [32]

Discoveries in Europe and North America during the first few decades of the twentieth century initiated a slight, but nevertheless tremendously significant, paradigm shift in understanding the human body. Rather than thinking about it as a vessel with fixed, inherited traits and capacities, scientists began to conceive of the body as an adapting organism that responded to its environment. Walter Cannon's *The wisdom of the body* (1932) presented one of the early, full-length statements of how the body seeks physiological stability and when it is altered 'then the various physiological arrangements which serve to restore the normal state when it has been disturbed' are bought into play. [33] The notion that the body could use a complex set of physiological processes to maintain its homeostatic condition in the face of significant external changes and pressures suggested that it might be possible to develop its physiological work capacity. The body, Cannon's work suggested, was not a fixed physiological entity and did not strictly follow the first law of thermodynamics as previously assumed.

The science/applied science lag

Although medical researchers continued to study human physiology through the 1930s and 1940s, there was a significant lag between the development of new knowledge in universities' and institutes' laboratories and its application in industry or the field of sport. Part of the reason was the inevitable and perpetual gulf that exists between theory and practice. A second major impediment was the philosophical approach that dominated sport in the 1930s and 1940s. This was the era of nascent commercialism in sport and the apogee of amateur athletics' emphasis on character development and education through sport. As a result, outcome and performance enhancement were of distinctly secondary importance. Finally, there was an irrefutable reality within the realm of sport itself that Ernst Jokl criticized even as late as 1958. 'Lord Kelvin's dictum', Jokl chided in 'The Future of Athletics',

> unequivocally accepted by the natural sciences as long ago as during the last quarter of the nineteenth century, viz. 'that no science can flourish without theory', *has made no impression whatever on physical training*. The latter remains one of the few disciplines of education whose affairs are still conducted without the benefit of theoretical concepts. [34]

A random survey of books on athletics in the late 1940s and early 1950s shows the basis and accuracy of Jokl's critique of physical education in

general, and athletic training in particular. *Physical conditioning: exercises for sports and healthful living*, a 1942 publication in the Barnes Sports Library, is a good example of how even though the basic principles of an emerging physiology of exercise were recognized by proponents of athletic training, they were applied in a highly circumscribed manner. [35] Like Pikhala, George Stafford and Ray Duncan defined fitness as those 'qualities best represented by strength, power, speed, skill and endurance for the task, plus proper enthusiasm (mental equilibrium, morale, and mind-set)'. [36] But unlike Pikhala or Christensen, there is no discussion of intensity in training sessions and variations between activity and rest although there is some attention to specificity (a concept understood through the study of Olympic athletes as early as 1929). [37] For Stafford and Duncan, the main guiding principle for athletic training is 'you learn to do anything whatsoever by *doing it*'. [38] Thus athletes who ran the 440 were instructed to train at distances of 350 to 500 yards. In other sports it was recommended that practices should last about the duration of an actual competition 'and accomplish about the same amount of work at the same speed'. [39]

Chapter 4 of this text, 'Sports Conditioning', presents specific conditioning activities for a number of sports ranging alphabetically from basketball and boxing, through football and gymnastics, to track and weightlifting. The most striking feature of these 'conditioning' exercises is that high-school athletes today would think they were simply warm-up callisthenics. *Physical conditioning* recommends athletes follow these exercises throughout a four-week period with their duration reducing from fifteen minutes in the first week to only five minutes in week four. [40] Stafford and Duncan do not, in any way, draw upon Pikhala, Christensen, Steinhaus or the Fatigue Laboratory's insights and their recommendations do not remotely approach contemporary regimes of training and conditioning. *Physical conditioning* does not direct athletes to long-term development through progressive resistance and varied intervals of work and rest. It does not indicate that a regime of exercises that is as sport-specific as possible, which is carefully designed to build power, strength, speed, agility, coordination, quickness, flexibility, local muscular endurance and cardiovascular aerobic capacity is the most proficient and useful approach to enhancing athletic performance. In fact, Stafford and Duncan's text does not suggest, or even imply, the two most basic principles of contemporary training and conditioning – the 'overload principle' and the 'principle of specificity' even though Steinhaus, for example, had discussed exercise specificity, overload training, cardiac output, blood composition, vital capacity and exercise metabolism as

early as 1933. [41] Stafford and Duncan do not even suggest that such a programme might be possible and desirable or that they had the knowledge basis from which they might formulate those principles or develop more elaborate training programmes.

Texts such as *Track and field athletics* (1947), *Championship technique in track and field* (1949) and the United States Naval Institute's *Track and field* (1950) also lack a sophisticated knowledge-base in exercise physiology. As a result, the general guidelines for training and conditioning do not contain the sophistication or levels of intensity that would characterize athletic training from the mid 1960s onwards. [42] Training in *Track and field athletics* reflects the pre-First World War approaches identified by Hildenbrand, where practice and drill are emphasized to refine technique, improve coordination, and enhance execution.

The main chapter on conditioning focuses on the variables that 'go to build and maintain physical and mental states which are most conducive to acceptable performance'. The chapter covers diet, elimination, exercise, weight, rest, sleep, staleness, stimulants and the use of tobacco. [43] The discussion of exercise is confined to two paragraphs which indicate that an athlete's regular daily routine is usually sufficient exercise to maintain health. When athletes must carry out manual labour, 'there exists the danger of over exercise', the authors warn. 'The ideal situation is one in which the athlete has no responsibilities requiring strenuous exercise other than the prescribed work in the event'. [44] The only discussion of physiological principles, found in the chapter 'Preliminary Season Preparations', focuses on warm-up and the development of muscle coordination. [45] While the workouts outlined in the text demonstrate a progressive workload, the principles involved in the development of the workouts are not discussed at all.

Championship technique in track and field begins by associating success in track and field with race and national histories before moving into principles of training. The 'key word in what we miscall training for track and field', Dean Cromwell and Al Wesson note, 'is moderation'. [46] The vital principle for training in track and field is preparing muscles for 'special duties'. 'No elaborate system of exercise is necessary if one will just remember that the aim is to develop muscular coordination rather than just muscle'. For Cromwell and Wesson, 'the two basic exercises that everyone should take are walking and chinning the bar'. The authors argue that people enjoy sports most when they win, which is why athletes train 'and do without a few little things like pie crust and tobacco', which is so easy to do 'that we don't need to call it training at all. It is just living a normal, moderate, regular life'. [47]

The Naval Institute's *Track and field*, 'prepared and published during WWII to provide the best standardized instruction in the sports selected to give the youth, training to be combat Naval pilots, the maximum physical and psychological benefits', emphasizes that 'the modern coach is a college graduate, versed in kinesiology, physiology, anatomy, hygiene and physics'. [48] The text presents an unsophisticated approach to training and conditioning. A distinction is made between 'core material' which focuses on 'circulatory-respiratory functions related to exercise' to promote maximal 'all-around physical condition' and 'supplementary drills and races' which are of short duration or 'acts of pure skill' that improve coordination and prepare athletes to 'meet sudden, emergency physical demands'. [49]

Despite the limited scientific information contained in training manuals through the inter-war and early post-Second World War period, athletes still sought ways to win, and they used performance-enhancing substances in many sports. Consistent with the conservation of energy, athletes used substances that maximized output on a given day rather than those that would build and expand performance capacity over time.

In this context, cycling provides an excellent case study. Unlike track and field, which was governed by the strict code of amateurism, cycling was thoroughly professionalized early on and winning was the riders' unabashed goal. Performance-enhancing substances have a long and open history in the sport. The type of substances used in the pre-Second World War period is noteworthy. Consistent with the dominant, scientific ontology of human performance, road racers from the 1800s through to the 1950s used a wide variety of 'race day' drugs – alcohol, opium, heroin, strychnine and amphetamines – to spike their performance on each particular day or to mask the pain incurred over the course of a multi-day ordeal. [50] The training and development of racers was not designed to enhance performance capacity; it simply focused on maximizing a given capacity and/or removing all sensations that would limit or inhibit the maximal use of that fixed capacity.

Although Joe Friel may not be aware of the mid-twentieth century paradigm shift in the ontology of human performance, his account of change in cycling mirrors that shift. He argues that Italian physician Francesco Conconi and his protégé Michele Ferrari initiated long-range planning and cyclists began to talk about periodization in training. It was then that cyclists began to use substances such as erythropoietin, steroids and human growth hormone rather than stimulants and analgesics. [51]

The cold war divide and the new paradigm in sport science

The Second World War and the beginning of the cold war transformed international, world-class, high-performance sport as approaches to training, the use of scientific knowledge to enhance performance and the resources directed towards the pursuit of the linear record changed dramatically. Stalwart proponents of the educative value of sport, even by the late 1950s, were yearning for the lost age of the near-mythological 'gentlemanly amateur' athlete, who had clearly faded away in the early post-war period. 'The last decade [1950s] has covered a strange period in the history of sport', Sir Roger Bannister argued, 'a far cry from what was envisaged by Baron de Coubertin'. 'It has seen the emergence of the new professionalism', he continued,

> not only in the sense of direct and indirect payment for sport, but also in devoting unlimited time and energy to sport, to the total exclusion of any other career – which has been rightly deplored. Every country seeks to enhance national prestige by physical achievements. . . . Too few questions seem to be asked about the means and the motives, provided the end of national glory is achieved. [52]

But, Bannister maintained, sport would 'survive the ethical and administrative problems' that beset it because, in the last analysis, sport is an individual affair with an individual meaning – it is 'not a national or moral affair': 'We run not because our country needs fame, nor yet because we think it is doing us good, but because we enjoy it and cannot help ourselves.' [53]

The actual record of post-war sport demonstrates that the focus in Olympic and world-class sport was elsewhere. Frucht and Jokl's statistical analysis of records in world-class sport from 1948 to 1960 revealed not just continual improvement but progress at an accelerating pace. [54] The features of world-class, high-performance sport that Bannister regarded as part of 'a strange period in the history of sport' were firmly entrenched by the 1960s and they would simply expand their influence rather than retreat into the background. Two of the central reasons were the strategic political objectives that particular national leaders held and the concomitant increased allocation of resources directed to world-class sport. Scientifically assisted, high-performance *sport systems*, and not individuals, became the main agents in world-class, high-performance sport in the post-war period. [55]

Although those changes were instrumental in the changed nature of world-class sport in the post-war era, the way high-performance sport developed was premised on the underlying ontology of human

performance. Two sports – weightlifting and track and field – seem to have been at the centre of the paradigm shift and, ironically, Bannister may have played a central role in the emergence of the new paradigm.

Calvin Schulman argues that by 1954 the public at large was obsessed with the pursuit of the four-minute mile. John Landy had shaved the time to 4:02. 'Two little seconds are not much', Landy said, '[b]ut when you are on the track those fifteen yards seem solid and impenetrable – like a cement wall'. 'It would take a miler of steel and imagination to break down decades of disbelief', Schulman wrote. 'It would take that special someone to summon the perfect blend of stamina and speed, with inner strength and supreme awareness of his own body, to batter down the cement wall and let the future of athletics charge into the promised land.' [56] It would actually take more – it would require a change in the approach to training and that change would, indeed, lead the 'charge into the promised land' although no one at the time recognized what that land would ultimately look like.

Efficiency alone would not make the barrier fall. In the pursuit of the four-minute barrier, Bannister, Wes Santee and Landy began to unwittingly remove a more fundamental one – the performance paradigm rooted in the conservation of energy. In pursuit of the four-minute mile, Bannister, Landy, Santee and other athletes and coaches began to use training techniques that would do more than perfect technique through drill; they began to build their performance capacities. As a result, rather than reflecting the apogee of amateurism, the 'miracle mile' is better thought of as a dramatic, 3:59.4 transition phase to the new paradigm of high-performance sport in the modern era.

With a medical degree that had followed bachelor's and master's degrees in physiology, Bannister was uniquely situated in the track world of his time; he was familiar with the experimental literature in physiology – and could well have known about the work of Pikhala, Christensen, Steinhaus, Hill and others. Irrespective of what exact literature he drew from, Bannister ran experiments on himself – including treadmill runs with oxygen enriched air – to enhance his performances; [57] used the new Swedish *fartlek* and interval training techniques that incorporated specified and very carefully planned work bouts alongside periods of rest; [58] and whenever possible, used the most advanced technology available to enhance his performances. [59] Without necessarily subscribing to the emerging ontology of human performance, Bannister's use of physiological knowledge and newly developing training techniques represents a significant incremental step towards the overturning of the old conservation of energy paradigm.

In weightlifting, Bob Hoffman – one of the most influential forces in American weightlifting in the 1940s and 50s – had assembled the most successful team of American weightlifters by recruiting widely and offering them work at the York Oil Burner company. Hoffman was not an innovator; he believed that success came when athletes with talent worked hard, kept high moral standards and lived in a congenial atmosphere. Hoffman's weightlifters' success was firmly rooted in the pre-war paradigm of human performance, which prevented him and many weightlifters from developing training techniques that would explicitly address the development of performance capacity. However, as John Fair notes, by the mid-1950s 'the course and character of American weightlifting' was changing as weightlifters began 'a deeper search for ways to alter the body's chemistry to induce more efficient muscular growth'. [60] The Soviet Union's use of testosterone in the 1952 Olympic Games, and John Ziegler's introduction of Dianabol to American weightlifters, reflected a new understanding of the ontology of human performance.

In the West, Donna Haraway argues that at the end of the Second World War there was a shift in the discourse of biochemistry from the mechanistic view of the first law of thermodynamics to one based in information theory. [61] At the molecular level, the discovery of DNA and the way its properties were understood drew upon the discourse of information theory – the body was coded, with instructions, messages, controls and feedback mechanisms which could be manipulated and maximized. Part of the reason for the paradigm shift lay in the number of biologists who were engaged in operations research during the war and their work with communications, codes and cybernetic systems led them to the new discourse. The ontology of human development and human potential shifted to the cellular level, where information was stored and could now be located and decoded to enhance performance. There was, however, a time lag between these developments in microbiology and applied sport science.

The Soviets, who had adopted a scientifically-based, instrumentally rational approach to sport in the early post-war period, made the jump from pure science to athletic performance enhancement much more quickly. [62] The reasons for the emergence of the new performance paradigm have never been fully documented but certainly one key factor was ideological. Stalin dictated that all scientific developments in the USSR must stem from the tenets of Marxism-Leninism and dialectical materialism. [63] The key text was Freidrich Engels's *Dialectics of nature* which argued that all entities – social and biological – were subject to the

'law of dialectics' and underwent continuous dialectical development and transformation. [64]

Throughout the 1920s and 1930s, Soviet geneticists argued about natural selection, species development and genetics. Within that debate, in defence of his theory of 'vernalization', the agronomist Trofim Denisovich Lysenko proffered a theory about the plasticity of the life cycle. The crucial factor determining the length of the vegetation period in a plant was not, Lysenko argued, its genetic constitution but its interaction with its environment. Because the theory was consistent with the *Dialectics of nature* and, more important Stalin's *Dialectical and historical materialism* and 'refuted' rival bourgeois and Menshevik theories, Lysenko's theory gained Stalin's support and approval. As a result, Lysenko rose to become the chief theoretician in Soviet biology.

Lysenko's chief argument was that contrary to all bourgeois theories of genetics, heredity was not determined by genes. The growth and development of all organisms depended on the laws of dialectics. Genetic endowment or heredity was largely irrelevant because organisms developed through the dialectical interaction of organism and environment – through the internalization of external conditions. Although Lysenkoism was a disaster for Soviet agriculture, its basic assumptions may well have opened the way to a new paradigm regarding the ontology of human performance. [65] Human performance capacity, within Lysenko's theory, could be altered and enhanced through the interaction of the organism with its environment. With state support, Lysenko's insights may have had a revolutionary impact on the concept of training and how the ontological foundation of human performance would be understood in the Eastern bloc during the post-war period. Irrespective of the motivation, the Soviet Union and later East Germany and other Eastern bloc countries invested heavily in the development of well-funded sport systems and put particular emphasis on the development of applied sport science.

Although interest in the scientific study of sport and exercise within North America and Europe began in the 1950s, it was not until the 1960s that the modern principles of athletic training were scientifically entrenched in the West. [66] In addition to the paradigm shift that led to the application of physiological principles to understand and enhance physical performance in athletics, there was a significant growth of institutional support for that undertaking. In Canada, for example, institutional support for sport science grew out of, and along with, the emerging emphases on applied physiology. The Canadian Medical Association in conjunction with the Canadian Association for Health,

Physical Education and Recreation established, at the Pan American Games held in Winnipeg in 1967, the Canadian Association of Sports Sciences. Renamed the Canadian Society for Exercise Physiology (CSEP), the group's goals were to 'promote and foster the growth of the highest quality research and education in exercise physiology' and 'to apply the knowledge derived from research in exercise physiology'. CSEP holds annual meetings, publishes its own journal, the *Canadian Journal of Applied Physiology* while also funding research in sport. [67] In 1970, the more exclusive Canadian Academy of Sports Medicine (CASM), open only to medical doctors, postgraduate medical trainees (residents/fellows) and medical students, was also established. CASM also hosts annual meetings, publishes a newsletter, has a fellowship programme in sports medicine and produces the *Clinical Journal of Sports Medicine*. [68]

The outcome of a paradigm shift in human performance

While the decisions individual athletes make concerning their training regimens or the use of a banned substance appear to be isolated and voluntary, in reality they take place within the context of a large, complex set of historically created and socially situated actions and relationships. Most important, and most often overlooked, is the fact that at the root of those systems and decisions is an image of the ontology of human performance. Over the course of the mid-twentieth century, for a variety of reasons (scientific, political, performance-related and accidental), a fundamentally important paradigm shift occurred in sport. Breaking away from the first law of thermodynamics over the middle years of the twentieth century, modern world-class sport now locates human performance within an ontological conception that permits and indeed promotes the continuous, scientifically assisted enhancement of athletes' performance capacities. Cycling can serve as an example of the impact this change has had upon the world of high-performance sport.

Mignon notes that during the first century of cycling (1850 to 1950–60), riders used stimulants and pain-killers to maximize their performance. [69] These substances and their intended effects were consistent with the ontology of human performance dominant at that time; they were not intended to help riders develop or expand their performance capacities, merely to allow them to use their existing capacities fully. The substances were 'home-made' and the knowledge surrounding them was passed, 'like kitchen recipes', 'from rider to rider and from *soigneur* to rider'. After the 1960s, however, systematic programmes were developed, and success in cycling, as in other high-performance sports, required

highly organized, scientifically based, large and well-funded programmes of development. 'The 1960s', Mignon argues,

> saw the emergence of a new type of individual, 'the trained athlete', different psychologically and physiologically from the man in the street. There also developed medical routines specific to the sports person, with specific treatments for specific injuries, but also specific care for preparation. This went hand in hand with the development of medical staff as a necessary condition of sports preparation: bio-mechanics for exercises and massages; nutritional scientists for vitamins and complements; psychologists for personal discipline and meditation; pharmacologists for the use of different medicines on the market. This rationale could also come to encompass non-medical uses of medicine such as steroids, analgesics, stimulants or tranquillisers. [70]

The paradigm shift in the ontology of human performance meant more than a new way of thinking about human capacities, important as that was. The paradigm shift focused attention upon performance-enhancement – the scientifically informed enhancement of human athletic performance – and this required tremendous institutional support as expert knowledge, specialized materials and innovative technologies were needed to push human physical performance to its outer limits.

The focus in discussions about the use of performance-enhancing substances in sport has centred on the athletes and the alleged magic bullets they take. Those who oppose the use of specific performance-enhancing substances want to increase and improve surveillance over high-performance athletes to deter them from using substances and to catch those who do. But their focus is misdirected for two reasons. First, the overall sociocultural conditions of modern high-performance sport are central to the use of performance-enhancing substances. Without a change in the social conditions of world-class sport, the behaviour of individual athletes will remain largely unchanged. Second, and even more fundamentally important, the behaviour of today's athletes and the sociocultural conditions in which they train and compete are based upon a fundamental ontological conception of human performance. This ontology emerged from the activities of a number of different people – pure scientists, applied scientists, political leaders, sport leaders, coaches and athletes to name just a few – and is now firmly entrenched. As long as this dominant, historically established ontology of human performance exists, reformers will not be able to fundamentally change the practices that are deeply woven into every dimension of world-class high-performance sport. What has now become the status quo is much more

deeply entrenched than reformers have recognized. Little will change until the ontology of human performance is thoroughly and critically examined.

Notes

[1] Bob Goldman, *Death in the locker room* (South Bend, IN, 1984), p. 32.
[2] Ibid.
[3] Goldman's evidence about the dangers of steroids and other performance-enhancing substances is very one-sided and misleading; cf Ray Tricker and David Cook, *Athletes at risk: drugs and sports* (Dubuque, IA, 1990) or William Taylor, *Anabolic steroids and the athlete*, 2nd edn (Jefferson, NC, 2002) for more balanced discussions.
[4] Goldman's actual question is not used because it is too fantastic and would, in isolation, undermine the credibility of the argument. Relying on the apparent truth value of Goldman's second claim, a paraphrased question closer to Mirkin's is used to make the argument.
[5] John Hoberman, *Mortal engines: the science of performance and the dehumanization of sport* (New York, 1992).
[6] Thomas S. Kuhn, 'Energy conservation as an example of simultaneous discovery', in Marshall Clagett, ed., *Critical problems in the history of science* (Madison, WI, 1962), pp. 321–56.
[7] See Yehuda Elkana, *The discovery of the conservation of energy* (Cambridge, MA, 1974); Kuhn, 'Energy conservation'; Cynthia Eagle Russett, *Sexual science: the Victorian construction of womanhood* (Cambridge, MA, 1989), pp. 106–7.
[8] See Russett, *Sexual science,* pp. 108–16.
[9] Cited in ibid., p. 107.
[10] Written in 1748, Julien de la Mettrie's *L'homme machine* was reissued in 1912 because it resonated with the scientific understanding of the human being at the time; see Julien de la Mettrie, *Man a machine* (La Salle, IL, 1912).
[11] Regarding physical education, see Paul Atkinson, 'The feminist physique: physical education and the medicalization of women's education', in J.A. Mangan and Roberta J. Park, eds., *From 'fair sex' to feminism: sport and the socialization of women in the industrial and post-industrial eras* (London, 1987), pp. 38–57. The doctrine was even used to understand the relationship between the mind and soul and the body's mysterious 'vital forces' of instinctual, physical drives. See Kenneth L. Caneva, *Robert Mayer and the conservation of energy* (Princeton, NJ, 1993), pp. 79–125.
[12] Eberhard Hildenbrandt, 'Milon, Marx und Muskelpille – Anmerkungen zur Kulturgeschichte des sportlichen Trainings' ['Milo, Marx, and muscle pills – observations on the cultural history of training in sport'], in Hartmut Gabler and Ulrich Göhner, *Für einen bessern Sport* ['For a better sport'] (Tübingen, 1990), p. 264.
[13] On Milo of Crotona, see Edward Gardiner, *Athletics of the ancient world* (Oxford, 1955), p. 6.
[14] See F. Hoole: *The science and art of training. A handbook for athletes* (London, 1888), p. 3, cited in Arnd Krüger, 'Viele Wege führen nach Olympia. Die

Veränderungen in den Trainingssystemen für Mittel- und Langstreckenläfer (1850–1997)' ['Many paths lead to Olympia: the changes in training systems for middle and long distance runners (1850–1997)'], in Norbert Gissel, ed., *Sportliche Leistung im Wandel* ['Athletic performance in transition'] (Hamburg, 1998), p. 50.

[15] Montague Shearman, *Athletics and football* (London, 1889), p. 7.

[16] Cited in Arthur Steinhaus, 'Chronic effects of exercise', *Physiological Reviews*, 13 (103) (1933), p. 110.

[17] Ibid., p. 104.

[18] Hoberman, *Mortal Engines*, p. 98; see also Hildenbrandt, 'Milon, Marx und Muskelpille'.

[19] See Frederick Taylor, *The principles of scientific management* (New York, 1911); Frank Gilbreth, *Motion study* (New York, 1911); and Frank Gilbreth and Lillian Gilbreth, *Applied motion study* (New York, 1917).

[20] Taylor, *Principles of scientific management*, pp. 43–74. See also Daniel Bell, 'Work and its discontents: the cult of efficiency in America', in *The end of ideology* (Glenco, IL, 1960), pp. 223–36.

[21] See Krüger, 'Viele Wege führen nach Olympia', p. 50.

[22] George A. Brooks, Thomas D. Fahey and Kenneth M. Baldwin, *Exercise physiology: human bioenergetics and its applications*, 4th edn (Boston, MA, 2005), p. 10.

[23] See Archibald Hill, 'The revolution in muscle physiology', *Physiological Reviews* 12 (1932), pp. 54–66 and Alison Wrynn, 'The grand tour: American exercise science and sports medicine encounters the world, 1926–1966', *International Sports Studies*, 24 (2) (2002), p. 8.

[24] See, for example, S. Hoogerwert, 'Elektrokardiographische Untersuchungen der Amsterdamer Olympiakämpfer' ['Electrocardiographic studies of the Amsterdam Olympic competitors'], *Arbeitsphysiologie* [Physiology of Work], 2 (1929), pp. 60–2; W.W. Siebert, 'Untersuchungen über Hypertrophie des Skelettmuskels' ['Studies on the hypertrophy of skeletal muscle'], *Zeitschrift der Klinische Medicine* [Journal of Clinical Medicine], 109 (1929), pp. 350–2; A. Vannotti and H. Pfister, 'Untersuchungen zum Studium des Trainertseins' ['Investigations on studies of being trained'], *Arbeitsphysiologie* [Physiology of Work], 7 (1934), pp. 153–5; and T. Petrén, T. Sjöstrand and B. Sylvén, 'Der Einfluss der Trainings auf die Haftigkeit der Capilaren in Herz- und Skelettmuskulatur' ['The influence of training on the absorption of capillaries in the heart and skeletal musculature'], *Arbeitsphysiologie* [Physiology of Work], 9 (1936), pp. 342–4.

[25] See L. Pikhala, 'Allgemeine Richtlinien für das athletische Training' ['General rules for athletic training'], in C. Krümel, ed., *Athletik: Ein Handbuch der lebenswichtigen Leibesübengen* [Athletics: A handbook of essential physical exercises] (Munich, 1930), pp. 185–90.

[26] See E.H. Christensen, 'Beiträge zur Physiologie schwerer körperlicher Arbeit' ['Contributions to the physiology of heavier physical work'], *Arbeitsphysiologie* [Physiology of Work], 4 (1931), p. 453.

[27] See Steven Horvath and Elizabeth Horvath, *The Harvard Fatigue Laboratory: its history and contributions* (Englewood Cliffs, NJ, 1973), pp. 18–24, 74–9.

[28] Brooks, Fahey and Baldwin, *Exercise physiology*, pp. 10–11.

[29] Horvath and Horvath, *The Harvard Fatigue Laboratory*, p. 3; see also pp. 52, 106–7.
[30] See ibid., p. 116.
[31] See ibid., p. 112.
[32] See ibid., pp. 104–22; see also pp. 122–6 for a bibliography of laboratory papers published on exercise.
[33] Walter Cannon, *The wisdom of the body* (New York, 1932), p. 25, see also pp. 19–26.
[34] Cited in Wrynn, 'The Grand Tour', p. 7 (emphasis added).
[35] George Stafford and Ray Duncan, *Physical conditioning: exercises for sports and healthful living* (New York, 1942).
[36] Ibid., p. 2.
[37] See Steinhaus, 'Chronic effects of exercise', p. 104.
[38] Stafford and Duncan, *Physical conditioning*, p. 11 (emphasis in original).
[39] Ibid., pp. 11–12.
[40] Ibid., p. 15.
[41] See Steinhaus, 'Chronic effects of exercise', pp. 103–40.
[42] George Bresnahan and W.W. Tuttle, *Track and field athletics*, 2nd edn (St Louis, MO, 1947); Dean Cromwell and Al Wesson, *Championship technique in track and field*, Olympic Games edn (Toronto, 1949); and V-Five Association of America, *Track and field*, revised edn (Annapolis, MD, 1950).
[43] Bresnahan and Tuttle, *Track and field athletics*, p. 21.
[44] Ibid., p. 31.
[45] Ibid., pp. 38–51.
[46] Cromwell and Wesson, *Championship technique*, p. 14; see also pp. 3–14.
[47] Ibid., pp. 21, 24, 28.
[48] V-Five Association of America, *Track and field*, pp. ix, 6.
[49] Ibid., pp. 8–9; see also 'Basis of conditioning', ibid., pp. 14–7.
[50] See Benjamin Brewer, 'Commercialization in professional cycling 1950–2001: institutional transformations and the rationalization of "doping"', *Sociology of Sport Journal*, 19 (3) (2002), pp. 294–5; Patrick Mignon, 'The Tour de France and the doping issue,' in H. Dauncey and G. Hare, eds., *The Tour de France, 1903–2003* (London, 2003), pp. 229–32, 241–3.
[51] Joe Friel, *The cyclist's training bible* (Berkeley, CA, 1996), pp. 16–18.
[52] Roger Bannister, 'The meaning of athletic performance', in Ernst Jokl and Emanuel Simon, eds., *International research in sport and physical education* (Springfield, IL, 1964), pp. 71–2.
[53] Ibid., pp. 72–3.
[54] Adolf Henning Frucht and Ernst Jokl, 'The future of athletic records', in Jokl and Simon, *International Research*, p. 436.
[55] Rob Beamish and Ian Ritchie, 'From chivalrous "brothers-in-arms" to the eligible athlete: changed principles and the IOC's banned substance list', *International Review for the Sociology of Sport*, 39 (4) (2004), pp. 359, 361–3, 365.
[56] Calvin Shulman, 'Middle-distance specialists committed to chasing that elusive dream', *The Times* (London), 4 May 2004, online at http://www.timesonline.co.uk/article/0,13849-1097363,00.html.

[57] John Bale, *Roger Bannister and the four-minute mile* (London and New York, 2004), pp. 54–5, 112–3.
[58] Ibid., pp. 23–4, 53–5, 75–6.
[59] Ibid., p. 76.
[60] John Fair, 'Bob Hoffman, the York Barbell Company, and the golden age of American weightlifting, 1945–1960', *Journal of Sport History* 14 (2) (1987), p. 180.
[61] Donna Haraway, 'The biological enterprise: sex, mind and profit from human engineering to sociobiology,' *Radical History Review*, summer 1979, pp. 206–37.
[62] Beamish and Ritchie, 'From chivalrous "brothers-in-arms"', pp. 359–60.
[63] Joseph Stalin, *Dialectical and historical materialism* (London, 1943).
[64] Friedrich Engels, *Dialectics of nature* (New York, 1940).
[65] See Trofim Lysenko, *Heredity and its variability* (New York, 1946) and Helena Sheehan, *Marxism and the philosophy of science: a critical history* (Atlantic Highlands, NJ, 1985).
[66] See Per-Olaf Åstrand and Kaare Rodahl, *Textbook of work physiology* (Toronto, 1970), esp. pp. 375–430; and Albert Taylor, *The scientific aspects of sports training* (Springfield, IL, 1975), esp. pp. ix, 5–45.
[67] See the Canadian Society for Exercise Physiology website at http://www.csep.ca.
[68] See http://www.casm-acms.org. On the scientific approach to physical education, see Donald MacIntosh and David Whitson, *The game planners: transforming Canada's sport system* (Montreal and Kingston, 1990), pp. 114–19.
[69] Mignon, 'The Tour de France', p. 232.
[70] Ibid., p. 233.