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Conference Paper · August 2016

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ABSTRACT

Sport and exercise science like most areas of life have been affected greatly by technological advancements. It is difficult to imagine modern sports and various sub-disciplines of exercise science without technologies. The use of technologies is, without exception, tainted with frustration and ambivalence. Paradoxically, it is the omnipresence of technology that has contributed most to people's inability to fully grasp the scope and depth of its influence and also uncertainty as to what role various technological advancements play in sports. Indeed, the influx of sport technologies has profoundly changed the landscape of sport and exercise science. Importantly, technology has in many ways changed what we think of as the athletic body. Therefore, this paper examines the impact of technology on sport performance, considering the theories of technology and quest for improved performance, types of sport technologies, the advantages and disadvantages of sport technologies in modern day sports. It is recommended that those managing, handling and using sport must be equipped to make wise choices on the type and use of sport technologies that would assist in the right performance.

Keywords: Performance, Sport Technology, Video Technology

1. Introduction

Sport world today is getting technological by combining natural athletic talent with advanced analytics and artificial intelligent to produce the best possible outcomes on the playing field of sports. Sport excite people as a triumph of human effort, with Barr (2016) stating that behind the scenes are a number of things that go into that triumph and at the top is technology. Technology has been utilized in sport for many years in various forms and play particularly vital role especially for the elite sport. Numerous attempts to define technology have yielded such an array of descriptions that one may resigned to the idea that technology is simply not definable. On the one hand, it is synonymous with science and rational thought, encompassing every little gadget ever held in hands. Cave and Miller (2015) states that technology plays an increasing role in assisting professional athletes, amateur runners and armchair fans to engage in the sport.

Technology is not just out there in the world, on the contrary, it is inside us as well. Indeed, on any given day our bloodstreams carry the remnants of ibuprofen and multivitamins, that many individuals have been technologized, or made more technologized, through artificial hearts, contact lenses, and other medical procedures. Technology is describe as any tangible, conceptual, or procedural element of modern sport and exercise science aimed at progress (Feenberg, 1999, 2003; Miah, 2004). The flexible definition allows everything from advancements in running shoes and eyewear to different ways of thinking about the body as technological. In the pre-digital age, the application of technologies in sport was heavily concentrated on athlete testing (diagnostics); improved sports equipment through better engineering and design, and utilized more at competitions. Thus, early examples of sport technologies were photo finish (1888),

physiological testing equipment (1920's), the instant replay screen (1955) and first use of electronic timing touch pads for swimming (1957).

Indeed, technology plays an important part in modern sport, with it being a necessary part of some sports (such as motorsport), and used in others to improve performance. The thematic applications of technology include, sporting equipment; clothing and wearable's; facilities; competition adjudication and formats; media broadcasting and communications and performance analytics. Hence, technology and sport have had something of rocky relationship over the years (Bass & Eynon, 2009). Turner (2013) opined that in the beginning sports and technology did not always seem like the most pairing. Considering the nature of sport and equipment use to play and with recent convergence of technologies many functions are fused into one small devices. However, the evolution of modern icons would not be possible without the specialization and personalization of sports science, this allowed athletes develop in possible ways.

Technology increasingly is playing a leading role in the development of sport and enhances performance in all faces. Thus, applications of technology allow for more effective training, stimulations, management and tracking of athletes, accuracy of results, enhanced spectator viewing, developing performance and preventing injuries, amongst many more functions (Busch, 1998). Technology in sports is a technical means by which athletes attempt to improve their training and competitive surroundings in order to enhance their overall athletic performance. It is thought of as a technical means or instrument utilized to pursue chosen ends. Hence, the paper investigates the impact of technology on sport performance.

2. Theories of Technology and Performance
Theories of Technology
One of the leading philosophers of technology Feenberg, (1999, 2003) outlined theoretical positions regarding technology. In essence, like lenses through which we can see the impact of technology. Depending on which lens it is look through, technological advancements may appear very positive or frighteningly negative. Heidegger (1998) noted that more fundamental criticisms of technology as ideology where technology, far from being the hand-maiden of man, comes full circle to be its master, where technology is sometimes seen to dominate its users by creating dependency and distorting human relations. Thus, the theories include: instrumentalist, determinist, substantivist, critical and dynamics.

Instrumentalist Theory
Instrumental theory offers the most widely accepted view of technology. It is based on the common sense idea that technologies are "tools" standing ready to serve the purposes of their users. Technology is deemed "neutral," without evaluative content of its own. But what does the notion of the "neutrality" of technology actually mean? Instrumentalists believe that all technology is a tool, largely under human control, that can be used for either positive or negative purposes.

They view the growth of technology as an evolutionary process, not as a series of revolutions or technological leaps (Levinson, 1996). Thus, see social conditions and human aspiration as the primary causes of change. The instrumentalist theory views technology as a neutral tool, something whose ends and means are separate. Instrumentalists see technological growth as the ultimate culmination of a long history of slow, gradual expansion. So, to use the example of high-tech tennis rackets, the instrumentalist perspective consider the new lightweight rackets as

just another tool in the ongoing quest for improved performance. Much like other technologies, athletes are simply using whatever tools are available to gain an edge over their competitors.

Determinist Theory

Technological determinists view technology as an autonomous force, beyond direct human control, and see technology as the prime cause of social change (Chandler, 1995). Determinists view the expansion of technology as discontinuous. That is, they see technological growth not as a gradual, evolutionary process, but as a series of revolutionary leaps forward (Kumar, 2001). Among the most widely-cited deterministic works is Alvin Toffler's (1971) book Future Shock. He concisely outlines the determinist's philosophy, after citing several examples of accelerated economic growth, he writes "behind such prodigious economic facts lies that great, growling engine of change technology" (p. 25). While acknowledging that technology is not the only force in social change, he adds, "technology is indisputably a major force behind this accelerative thrust" (p. 25) and "by now the accelerative thrust triggered by man has become the key to the entire evolutionary process of the planet" (p. 485).

Technological determinists, united in their belief that technology is an autonomous and revolutionary force, often differ in their opinion of the morality of technology. Determinists commonly have either a radically utopian or radically dystopian opinion on technology (Kaplan, 1996). Utopian determinists believe that technology is a positive and uplifting force that will, over time, mitigate or eliminate most of the ills that afflict humanity. They believe technology is leading society towards an ever more utopian existence. Conclusively, this techno-utopianism assumes the neutrality of technological innovation and its endorsement of a technologically determinist view of history (Robins & Webster 1999). Dystopian determinists believe that technology is an inherently evil, or dehumanizing, force that will lead, inevitably, to the moral, intellectual, or physical destruction of humankind.

The determinist theory states that technology is neutral, or value-free, but it has become autonomous, or self-directed. So, using the tennis racket example again, the determinist perspective would consider the new racket as a tool that, once allowed into the game, would take on a "life of its own" and prompt athletes to use it whether they wanted to or not. The very presence of the racket would mean that once one athlete decides to use the equipment, others would feel the pressure to do so as well. Also, if the new racket gives high velocity servers an even greater advantage, then this one technology could change the way the game of tennis is played forever.

Substantivist Theory

Despite the common sense appeal of instrumental theory, a minority view denies the neutrality of technology. Substantive theory, best known through the writings of Ellul (1964) and Heidegger (1998), argues that technology constitutes a new type of cultural system that restructures the entire social world as an object of control. This system is characterized by an expansive dynamic which ultimately overtakes every pre-technological enclave and shapes the whole of social life. Another theoretical position is called the substantivist theory, and this involves the view that technology is neither neutral nor completely within our control. Substantive theory claims that what the very employment of technology does to humanity and nature is more consequential than its ostensible goals. This view is the most pessimistic in terms of how it would regard the new tennis racket (Tenner, 1996). New rackets would be viewed as having certain values attached. For instance, while the racket designers may have simply been trying to build a better, lighter racket that allows players to hit the ball harder and faster, the consequences of this new design

seem to value speed and power over finesse. The substantivist position also shares the determinist view that, once unleashed, technologies have the potential to gain a direction of their own, and it will become increasingly difficult to go back to more "natural" forms of performance enhancing techniques. In the end, technology will drive what sports we play, how we play them, and who is best suited to participate.

Critical Theory

Modern technology is no more neutral than medieval cathedrals or The Great Wall of China; it embodies the values of a particular industrial civilization and especially of its elites. Critical views of technology recognize that, ultimately, technologies should be controlled by us. Feenberg (1999, 2003) advocates moving toward a more critical theory of technology. Critical theory argues that technology is not a thing in the ordinary sense of the term, but an "ambivalent" process of development suspended between different possibilities. This "ambivalence" of technology is distinguished from neutrality by the role it attributes to social values in the design, and not merely the use, of technical systems. On this view, technology is not a destiny but a scene of struggle. It is a social battlefield, or perhaps a better metaphor would be a parliament of things on which civilizational alternatives are debated and decided. A critical theory sees the politics and values associated with technology. So, critical perspectives of the influx of new tennis racket technologies would call for more open debates on the politics of the technique and ask questions such as "Who will have access to this equipment?" "Who decides whether the equipment should be legal or restricted on the professional tour?" and "What will be the long-term effects of new racket technologies on the game?"

Dynamic Systems Theory

Dynamic systems theory has emerged in the movement sciences as a viable framework for modeling athletic performance. Thus, from a dynamical systems perspective, the human movement system is a highly intricate network of co-dependent sub-systems (respiratory, circulatory, nervous, skeletomuscular, perceptual) that are composed of a large number of interacting components (blood cells, oxygen molecules, muscle tissue, metabolic enzymes, connective tissue and bone). In dynamical systems theory, movement patterns emerge through generic processes of self-organization found in physical and biological systems (Williams et al., 1999)

Dynamical systems theorists claim that the number of biomechanical degrees of freedom of the motor system is dramatically reduced through the development of coordinative structures or temporary assemblages of muscle complexes (Turvey, 1990). The reduced dimensionality/complexity of the motor system encourages the development of functionally preferred coordination or attractor states to support goal-directed actions. Within each attractor region (the neighborhood of an attractor) system dynamics are highly ordered and stable, leading to consistent movement patterns for specific tasks. Variation between multiple attractor regions, however, permits flexible and adaptive motor system behaviour, encouraging free exploration of performance contexts by each individual. The paradoxical relationship between stability and variability explains why skilled athletes are capable of both persistence and change in motor output during sport performance. Indeed, variability in movement behaviour permits performers to explore task and environmental constraints in order to acquire stable motor solutions over time and enhance motor learning. Handford et al. (1997) provide a more detailed explanation of the stability-variability paradox in skill acquisition.

A concern aired for some time by many influential investigators is that biomechanical research, and more notably sports biomechanics research, needs to move from its descriptive phase to a more analytical level (Elliott, 1999). Bartlett (1997) suggested that most performance-oriented sports biomechanics research lacks a sound theoretical rationale and seldom makes reference to motor control theory, universal biomechanical principles, or the fundamental laws of physics that govern them. Thus, dynamical systems theory could provide a relevant theoretical framework for performance-oriented sports biomechanics research, as it offers an interdisciplinary approach to the processes of co-ordination and control in the human motor system (Glazier, Davis & Bartlett, 2002).

3. Types of Sport Technologies

Technology is changing the face of modern sports, sports psychology and coaching. State-of-the-art technologies are used to optimize performance in sports as diverse as cycling, speed-skating, swimming, golf, skiing, surfing, football/soccer ball, tennis racket and ball, running, facilities and many more. Technology in sport today is found in countless forms with each innovation has potentially positive and beneficial outcomes. Understanding the implications of sport technologies involve basic typology used in classifying, these are done in six types of sport technologies though not mutually exclusive, in some cases same technologies could fit into multiple categories. The categories include: self-technologies, rehabilitative technologies, landscape technologies, movement technologies, implement technologies and database technologies. While some of the technologies are yet to make an impact on sport, understanding of many types of sport technologies help to obtain a better perspective on which technological options athletes eventually have access to and impact on sport performance.

Self -Technologies

This represents the most obvious and distributing for many people form of technology due to the potential of fundamentally and often permanently alter an athlete's physical or psychological being/make-up. Banned performance-enhancing drugs are the most recognizes of these technologies. Self-technologies encompass other kinds of athletic innovations, of which are also controversial. Others include surgical procedures, prosthetic/bionic limbs, sport psychological interventions and genetic engineering are all classified as self-technologies.

The presence of certain self-technologies in sport may be seen as future such as bionic prostheses (as used by Oscar Pistorius). Scientists working on a muscle-building vaccine derived from engineering genes already recognised the implications of their work for sport. Thus, the generic alteration of athletes or gene doping is a human genome projects to map all the genes in the human body, which can increases the muscle mass. Although it is unclear whether the long-term effects are safe or not.

Under this view, technology is ethically neutral. It is neither good nor bad in itself. Rather, what matters is the end or purpose to which the technology is merely the means. While equipment such as a prosthesis or a wheelchair are fundamental for some persons with a disability to carry out their daily living (Haisma, vanDerwoude, Slam, Bergen & Bussmann, 2006; Pasquina, Bryant, Huang, Roberts, Nelson & Flood, 2006), advances in this technology, such as an energy storing prosthetic foot, make a lower limb amputee's gait faster and more efficient (Brodtkorb, Henriksson, Johanesen-munk & Thidell, 2008).

Landscape Technologies

This form of technology involves the sporting environment which include the way spectators watch sport events. Prominent landscape technology is the increase of modern multipurpose sport complexes, complete with JumboTron screens retractable domes, soaring cameras, mondo tracks and artificial grass. Bates (1996) argues that modern athletes have an intimate relationship with the technological sporting landscapes. Track and field athletes use new tactics because they can monitor their competitors on the JumboTrons coming down the home stretch. Some discus and javelin throwers even throw. The high-tech stadium is interesting in often attempt to replicate the atmosphere of other traditional style stadiums.

Sport and exercise science, like most areas of life, has been affected greatly by technological advances (Wintler, 1996). In fact, it is difficult to imagine modern sports and the various sub-disciplines of exercise science without the technologies that currently taken for granted. Can you imagine doing biomechanical analyses without computers, performing VO2max testing without underwater weighing, or training for Olympic-level track and field events without modern training techniques and assessment procedures? How about watching sports on television with only one or two camera angles?

Global positioning system (GPS) uses 24 satellites and ground stations as reference points to calculate geographic locations and accurately track a specific activity. For example, using a portable GPS unit provides information about altitude, distance, time, and average velocity during hiking. A graph depicting the uphill and downhill portions of the terrain is also provided. Global positioning system can be used in conjunction with accelerometers to assess and monitor physical activity (Schutz & Herren 2000; Rodriguez, Brown & Troped 2005; Troped et al. 2008). As the small receivers become more affordable and accessible to the general public (in laptop computers and mobile telephones), GPS may be more widely used to assess and promote physical activity.

Indeed, the influx of sport technologies has profoundly changed the landscape of sport and exercise science, and perhaps more importantly, technology has, in many ways, begun to change the athletic body. Paradoxically, it is the omnipresence of technology that has contributed most to inability to fully grasp the scope and depth of its influence, adding to uncertainty as to what role various technological advancements should play in our lives.

Implement Technologies

It includes equipment that athletes use or that they kick, hurl or otherwise propel. Other examples include football/soccer helmets equipped with warning devices and radios; shark suits that allow swimmers to move efficiently slice through the water and high-tech running shoes, golf clubs and tennis rackets. The interesting controversy involving these kinds of technologies is the use of fish-finding computers in sport fishing. This technology uses tools (pedometer or balance board), media (video, audio, or both), and social interaction (playing with another person) to persuade individuals to adopt the behaviour without their actually knowing it.

Rehabilitative Technologies

These are substances and procedures used to treat moderate to severe injuries make up rehabilitative technologies. They also include medicine used by healthy athletes who just want to counter the otherwise debilitative effects of their training regimens. Typically, these technologies are located in sports clinics and training facilities and are administered by specialists in athletic training or sports medicine. Rehabilitative technologies include any kind of anti-inflammatory

chemical, such as acetylsalicylic acid. Rehab technologies also include whirlpool machines and ultrasound equipment that athletes use to treat sore muscles and joints. More recent developments such as electronic stimulation or slim send currents into the affected area to stimulate blood flow and aid in the healing process. While not technological in the usual sense, techniques such as acupuncture and chiprate adjustments are also used in addition to mechanical and computerized treatment Rehab technologies may also be viewed as performance enhancing because they allow athletes to train and compete at a level they otherwise could not.

Movement Technologies
It refers to those devices and procedures that are designed to assess the form and efficiency of an athlete's body. The most common of such include videotape analysis, although there are much more sophisticated instruments that provide detailed computerized information on an athlete's biomechanics. On like the other form of technology movement technologies are often not visible within the competitive arenas. Besides helping to improve an athlete's existing technique, the data yielded by movement techniques may also facilitate conceptual or stylistic shifts that allow the athlete to compete in a mechanically, aesthetically and kinesthetically novel manner.

The introduction of technology as profoundly change the nature of sport and sports participants. The use of high-speed video technology (goal-line technology) wish have change the response to ball that crosses the goal line without officials' presence or sightseeing. The use of (mini) digital cameras, body-worn sensors, wireless transmission, and mobile computers has revolutionalised the way coaches and sport psychologists interact with individual players and teams. Individual body-worn sensors can yield real-time biometric player data that may inform coaching decisions during a game or may be used to analyze a player progress over time. Warburton and colleagues (2009) reported that interactive video game cycling significantly increased steady-state heart rate and energy expenditure compared to traditional cycling at constant, submaximal workloads; the two forms of cycling (traditional and interactive video game cycling) resulted in similar ratings of perceived exertion.

Database Technologies
It involves computer innovations that allows athletes and coaches to know everything they need to know about their opponents and themselves. Database programmes have greatly affected the way that many and most professional coaches and players do their business. Informational feedback technologies (a Nike GPS sports watch; a Polar heart rate monitor) allow individual athletes to continuously track their progress on important physiological and performance parameters. Even when not training for an Olympic gold medal, technology can play a positive and supporting role, helping people to get motivated in adhering to a healthy exercise routine, or in rehabilitating after injury.

Competitive level of modern sports, especially high level of sport performance has been close to the limits of natural conditions of mankind, the idea of using the natural advantages, original training methods, to limit the movement of human beings, has long been a dream. The large number of computer technology, biological engineering, new materials and energy technology, information technology, and theory of modern science and technology have been widely used in sports fields, making the face of sports and sports training environment greatly changed and improved, training methods updated, site equipment improved, greatly improved the level of competitive sport, the wide range of functions and effects of sports therefore has been fully exhibited.

4. Technology and Quest for Performance

Sports gear such as clothing and footwear should be user-friendly and include valuable properties such as strength, flexibility, density, thickness, durability, toughness, resistance to moisture and more importantly cost. Footwear is generally considered more for comfort and injury avoidance rather than performance enhancement, whereas clothing such as the full body suits used in swimming are often claimed to rationalise the competitor's performance times where winning or losing the race is measured in hundredths of a second.

Sporting equipment such as the composite tennis racket has been created in order to provide enhanced ball speed, and reduce the potential vibration that can lead to a condition known as tennis elbow (damage to the small blood capillaries in the muscles and ligaments that surround the elbow joint). In other sporting equipment such as the golf club, the overall mass of the club has decreased which is believed to result in a greater achievable distance and possibly a more precise shot. The bicycle has also undergone modern day advances with the development of specialist wheels, pneumatic tyres, break levers and pedals, which are all aimed at increasing stability and rigidity of the bicycle.

Prosthetic devices have also been constructed for those athletes with a specific disability. Examples include the springlite prosthesis device created for those athletes deficient of a lower limb, which acts with a 'springboard-like' effect where with each step as the runner strikes the track, the device returns energy and permits running gait. Wheelchair devices used in sporting activities have also become more sophisticated, for example, with sharply slanted back wheels in tennis to allow the player to move swiftly across the court from side to side, these and many more ways technology and quest for performance improved.

5. Summary

Sports as a special social phenomenon, has become a modern technology accessories. The word of sport is changing because of technology, as technology plays large roles in daily lives, it also play a large role in changing the body. Thus, technology continues to change the way sports are played, how injuries are treated, what kinds of sports are played and enhances performance outcomes. Sporting technologies are man-made means developed to reach human interests or goals in or relating to a particular sport. It is a technical means by which athletes attempt to improve their training and competitive surroundings in order to enhance their overall athletic performance. It is the knowledge and application of using specialised equipment and the latest modern technologies to perform tasks more efficiently. Therefore, coaches and athletes must be aware of sport technologies, and make wise choices about how it affects their performances.

6. References

Barr G. (2016). *How artificial intelligence plays into the future of sports technology*. Sport Techie

Bartlett RM (1997). Current issues in the mechanics of athletic activities: a position paper. *Journal of Biomechanics, 30,* 477-486.

Bartlett RM (2000). Principles of throwing. In V. M. Zatsiorsky (Ed.), IOC *Encyclopedia of Sports Medicine: Biomechanics in Sport* (Vol 6, 365-380). Oxford: Blackwell Science

Bass, R. & Eynon, B. (2009, January 7). *Capturing the visible evidence of invisible learning*. Retrieved from http://www.academiccommons.org/commons/essay/capturing-visible-evidenceinvisible-learning

Bates BT (1996). Single-subject methodology: An alternative approach. *Medicine and Science in Sports and Exercise*, *28*, 631-638

Brodtkorb, T., M. Henriksson, Johannesen-Munk, K. & Thidell, F. (2008). Cost-effectiveness of c-leg compared with non-microprocessor-controlled knees: A modeling approach. *Archives of Physical Medicine and Rehabilitation, 89*, 24–30.

Busch, A. (Ed.). (1998). *Design for sports: The cult of performance*. New York, NY: Princeton.

Cave, A. & Miller, A. (2015). Technology in sport: the speed of science. *The Telegraph*.

Chandler, D. (1995). Technological or Media Determinism. http://www.aber.ac.uk/~dgc/tdet01.html)

Ellul, J. (1964). *The technological society*, J. Wilkinson, trans. (New York: Vintage, 1964), p. 14.

Elliott BC (1999). Biomechanics: an integral part of sport science and sport medicine. *Journal of Science and Medicine in Sport, 2*, 299-310.

Feenberg, A. (1999). *Questioning technology*. New York. NY: Routledge.

Feenberg, A. (2003). *Questioning technology*. New York. NY: Routledge.

Glazier PS, Davids K & Bartlett, R. M (2002). Grip force dynamics in cricket batting. In K. Davids, G. Savelsbergh, S. J. Bennett, and K. Van der Kamp (Eds*.), Interceptive Actions in Sport: Information and Movement*, (311-325), London: Taylor and Francis

Handford, C., Davids, K., Bennett, S., & Button, C. (1997). Skill acquisition in sport: Some implications of an evolving practice ecology. *Journal of Sports Sciences, 15*, 621-640

Haisma, J., Van Der Woude, L., Stam, H., Bergen, M., Sluis, T., & Bussmann, J. (2006). Physical capacity in wheelchair-dependent persons with a spinal cord injury: A critical review of the literature. *Spinal Cord, 44,* 642 – 52.

Heidegger, M. (1998). *The question concerning technology and other essays*. Chicago: University of Chicago press.

Kaplan, M. A. (1996). *Thinking about technology*. The World & I., 287-300.

Kumar, K. (2001). *From Post-Industrial to Post-Modern Society: New Theories of the Contemporary World*. Oxford: Blackwell.

Levinson, P. (1996). *On behalf of humanity: the technological edge. The World & I.*, 301-313.

Miah, A. (2004). *Genetically modified athletes: Biomedical ethics, gene doping and sport.* London, UK: Routledge

Pasquina, P.F., P.R. Bryant, M.E. Huang, T.L. Roberts, V.S. Nelson, and K.M. Flood (2006). *Advances in amputee care. Archives of Physical Medicine and Rehabilitation*, *87*(. 3S): 34–43.

Robins, K. & Webster, F. (Eds.). (1999). *Times of the Technoculture: From the Information Society to the Virtual Life*. London: Routledge.

Rodriguez, D. A., Brown, A. L & Troped, P. J (2005). Portable global positioning system units to complement accelerometry-based physical activity monitors. *Medicine and Science in Sports and Exercise*, *37*(11) 572-581.

Schutz, Y & Herren, R (2000). Assessment of speed of human locomotion using a differential satellite global positioning system. *Medicine Science Sports Exercise. 32*, 642-646.

Tenner (1996). *Why things bite back: Technology and the revenge of unintended consequences.* New York: Alfred A. Knopf.

Toffler, A. (1971). *Future Shock. (Bantam edition)*. New York: Bantam Books.

Troped, P. J., Oliveira, M.S., Matthews, C. E., Cromley, E. K, Melly, S. J & Craig, B. A (2008). Prediction of activity mode with global positioning system and accelerometer data. *Medicine and Science in Sports and Exercise, 40* (5), 972-978.

Turner, G. M. (2013). *The limits to growth model is more than a mathematical exercise; reaction* to R. Castro, 2012, Arguments on the imminence of global collapse are premature when based on simulation models', GAiA 21/4, pp. 271– 273. GAiA, 22, pp.18-19.

Turvey, M. T (1990). Coordination. *American Psychologist, 45*, 938-953

Williams, A. M, Davids, K & Williams, J. G (1999). *Visual Perception and Action in Sport*. London: Taylor and Francis.

Winkler, W. (1996). Computer-controlled assessment and video-technology for the diagnosis of a player's performance in soccer training. In M.D. Hughes (Ed.). *Notational analysis of sport, I and II* (27-43). Cardin: UWIC.