SPORTS ERGONOMICS: An important perspective of Sports Physiotherapy

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Ergonomics is a science in order to obtain the best with least efforts with highest satisfactions for the own and public welfare. This term was coined by Jastrzebowski in 1857 and in modern times, this term was used by Murrel in 1949. Ergonomics emerged out of a necessity to understand how to optimize human performance and how to avoid breakdown of physical, physiological and psychological resources. Ergonomics has become an influential profession worldwide, reflected by common principles in designing products and artifacts for human use in wide variety of domains. These areas include not only work and industry but also domestic, leisure and sports contexts (Tofaute, 2009). Often people believe that the word ergonomics is only applied to the office environment, but the main purpose of ergonomics is to ensure safe movement of the human body during a task (Dimitrov, 2006).

The main principle of ergonomics is that the target to accomplish as well as the equipment to be used is designed with the operator in mind. In sports and exercise this means that the challenges inherent in the activity are within the capabilities of the individual and that equipment used is suited to the athlete concerned. Therefore, sport ergonomics deals with the human structuring of the socio technical systems in sports (Tofaute, 2009). The socio economic system affects the people on one hand and technical products on the other hand. In science, ergonomic systems are constantly researched and in next step explanatory models are derived from this data. This in turn can be used to make the environment more ergonomic with the knowledge that can be used in designing of products and services (Dimitrov, 2006).

A sport is a very broad term used for a wide range of activities, involving many areas and different agents, and the use of technology for each one is different. In general terms, the higher the technological level of an innovation, the lower is its marginal contribution. Thus, the latest innovations generate the most value in the top level of sports practice. If athletic performance in

a certain sport is achieved with the help of technology, we can describe that sport as having a technological basis (Dimitrov, 2006). Technology adds value to this kind of sport, and serves the following functions:

1. Performance: Consistent improvement in modern athletic performance has been greatly aided by continuous innovation in equipment, training, nutrition and sports clothing. Over the years, sport has acquired high levels of professionalism and commercialization, helping it to become deeply embedded in the fabric of society, a fact that only serves to increase the pressure to win. And it is this pressure that feeds the need for continued application and the search for new technologies that will assist the athlete in achieving even better results. It is difficult to imagine this positive trend changing in the future, given the relentless demands placed on athletes from competition, sponsors, trainers and the general public: the demand for enhanced performance and better results, especially from elite athletes (Dimitrov, 2006).

2. Comfort: The need for comfort in sports practice can be seen to a large extent in all categories and disciplines. This need is directly related to the characteristics of the given sport and the degree to which it is practiced. Thus, higher levels of comfort are needed in:

- Sports demanding intense and extended efforts.
- Sports demanding protection against the weather. The search for comfort and wellness is not exclusive to athletes; they are important factors for every consumer of sports goods, And the growing demand for improved quality of life and enhanced performance suggest that future consumers will expect even higher levels of product comfort.

3. Security and safety: In risky sports, security means active and passive protection against accidents, which involves a high level of technology. With the growing trend towards ‘adventure’ and higher-risk sports, it is clear that the technological demand for developing security aspects in sports practice will continue to rise in the future.

Key elements in the field of sports ergonomics involve intelligent use of new technologies, such as:

- Use of Smart materials

• New design methods

• Customized production techniques (Dimitrov, 2006, Oslo Manual)

Influence of science in Sports Ergonomics:

There has been an analysis of the different aspects related to technology transfer oriented to improving the use and application of technology in sports. Sports equipment, especially those made for elite athletes, is an excellent entry point for new technologies. The latest technologies can be very expensive, producing minor additional improvements in performance, security and comfort when compared with more traditional technologies. However, elite athletes find enormous value in even the smallest improvement, above all in performance, due to the extreme levels of competition and the fact that they are already at the highest levels of performance. Moreover, the great value that technology has created throughout history creates a positive attitude with technologies among the users. Thus, sports equipment has incorporated technology from various fields including nanotechnology, the textile industry and above all, the aerospace industry. (Dimitrov, 2006, Oslo Manual)

Nanotechnology: This is a set of sciences and technologies that allow the manufacturing and control of molecular structures and its atoms at the nanometre scale (1 billion nanometres = 1 metre). Nanotechnology has multiple applications in clothing, because controlling the nanostructure of the surfaces can change the physical, chemical and biological properties of the materials. These variations of properties open a new world of possibilities for the clothing industry, and by association, the sports clothing industry. Using these techniques, intelligent materials can be produced, such as the trousers worn by Tiger Woods, which are resistant to coffee, tomato sauce and even wine stains. Moreover, nanotechnology can incorporate conductive fibres into the fabrics, in order to create electronic clothing with sensors or integrated chips, or create a fabric even more than spider silk, which is stronger than steel and more elastic than nylon. There is a potential for the development of an enormous number of applications for the sports industry, which will both enhance performance and improve comfort. The continued development of nanotechnology will contribute to the creation of innovations with high added value for the end user, and processes clearly better than the conventional (Oslo Manual)

Aerodynamics: The relevance of aerodynamics to sports equipment is proportional to the speed that is achieved while practicing, since wind resistance increases exponentially with the athlete's speed. This is why aerodynamic design is limited to such sports as skiing, cycling, motor sports, although in sports where less speed is achieved (like athletics, skating, or swimming), aerodynamic suits are also used. Aerodynamic profiling has been introduced in helmets, suits, bikes and even skis, adding to the improvement achieved through correct posture of the user (Dimitrov, 2006, Oslo Manual).

Materials: Innovations in materials are endless. In sports with a high technological basis, almost every important brand has developed its own material and manufacturing techniques, and the use of technology is intensive for the majority of the ranges. A lot of these new materials come from the aerospace industry, and they greatly exceed the characteristics of traditional materials in terms of flexibility, durability, strength, resistance, thermobalance and sensation. Such materials include Kevlar, carbon, graphite, vulcanized rubber, glass fibre, elastomeric materials, thermo mould able materials, to name but a few. (Dimitrov, 2006, Oslo Manual)

Materials- nanotechnology: Because it is still an emerging technology, its application to sports has not yet been significant. However, because of the incredible properties of nanomaterials, it is expected that the number of applications will multiply in the coming years. Nanomaterials offer superior levels of light weight, hardness, resilience, flexibility, and many other characteristics. In cycling for example, nanomaterials have been used in the production of new bikes, which are much lighter yet with the same structural strength. In golf they are used to create lighter clubs and balls that fly straighter. And in winter sports, nanomaterials are used to produce more flexible skis, with better grip and control (Dimitrov, 2006, Oslo Manual).

Design and manufacturing techniques: Modern design and manufacturing techniques have evolved largely in the last decade. Some of the materials and techniques used in the highest ranges of cycling equipment, for example, are on a par with those used in F1, and concepts such as biomechanics and ergonomics have made impressive strides. Other manufacturing techniques have been imported directly from the aerospace industry, with the very latest developments in Computer Assisted Design now a major component of the design process. These techniques elevate the standard of the final product features, such as flexibility, lightness, solidness,

adherence and control. Examples include crossed laminations, sandwich-like materials, micro pores and strategic material placement. (Dimitrov, 2006)

Assessing Individual characteristics:

Databases accessible to ergonomists provide numerical information about human characteristics and activities and how they vary between individuals. These numbers are expressed as mean or average and as a range or quartile. One difficulty is that having an average value for one characteristic does not guarantee being average on others. Hence it is necessary to consider individual variation. These variations are addressed for anthropometry, physiological capabilities and performance measures. (Reilly T, 2010)

Assessing physiological capabilities:

A hallmark of sports ergonomics is the correspondence between the individual and the task or sports. This match becomes more refined as participants become skilled in specific sports and acquire physiological adaptation to their tailored training program. Any method of testing individual capabilities should resemble key aspects of the sport in question. Where possible any test apparatus should be linked to the sport if inference about fitness level and training prescription are to be drawn from the observations. These observations are drawn by field tests, physiological assessment (aerobic and anaerobic capacity and power, muscle strength, mobility and agility). (Reilly T, 2010)

Role of Physiotherapy:

Sportsmen are subjected to contract musculoskeletal injuries. For instance, shoulder injuries are frequent in relation to physical activity in sports event and training with overhead or repetitive arm movements (Hume et al, 2006). Common injuries for the shoulders such as Rotator cuff injury/impingement syndrome may occur after unaccustomed high intensity repetitive movements (e.g., swimming) or low load repetitive work. The risk of musculoskeletal damage is correlated to the physical and psychological attributes of the performed movement. The known physical external risks include a fixed erected posture, repetitive arm movement, heavy load, insufficient rest, temperature and static posture (Madeleine, 2010).

Internal individual risk factors such as anthropometry (age, height and body mass for instance), gender, physical capacities (Muscle force, endurance and fitness for instance) and personality also play a role in these injuries.

Biomechanical analyses have to date contributed to enhance our knowledge of the underlying causes of movement (McGinnis, 2005). This is supported by the fact that the sole use of observation methods correlate weakly with quantitative biomechanical measures.

Biomechanical assessments of human performance contribute to delineate damageable load In ergonomics, kinematics recordings from video recordings and inclinometers are made in real working conditions (Hansson et al, 2006; Madeleine & Madsen, 2009). In sports, timing devices and 2D video recordings are often collected in relation to physical activity (McGinnis, 2005).

Physiological:

Physiotherapists use physiological tools to assess the physical and muscular load during physical activity using heart rate, Electromyography (EMG) and Mechanomyography (MMG) recordings. The recordings and analysis of EMG and MMG data in fresh, fatigued and injured conditions provide important insight into adaption mechanisms. Such an understanding is required for the interpretation of the changes in the motor control and the validation of computer simulation and modelling. These interpretations help physiotherapist in designing rehabilitation management and injury prevention (McGinnis, 2005; Madeleine, 2010)

Kinetics:

Kinetics is the term given to forces generating movement. Internal forces are generated by muscle activation, ligaments and joints while external forces are issued from the ground or external loads. (Madeleine, 2010).

Methods of Recording:

The internal forces are in most cases extremely difficult or even impossible to measure and are normally estimated by using computer model. The external forces, on the other hand, can be recorded by various types of sensors and analyzed in many ways. The recordings and analysis of kinetic data are of great importance as it enables a sound interpretation of the mechanisms

involved in movement strategies (McGinnis, 2005; Nigg & Herzog, 2007). Various devices used for measurement of external forces include: force and pressure sensors, force platforms.

Kinematic recordings:

Physiotherapists use kinematic recordings in the assessments of segmental motion in sports. Instruments commonly used are accelerometers and gyroscopes, angular sensors and optic imaging systems in detecting and correcting the faulty biomechanics (Muybridge, 1984).

Sports ergonomics devices help the physiotherapist to correct the abnormal biomechanics which arise due to static anatomical abnormalities or functional secondary abnormalities. Thus play a key role in increasing the performance as well as injury prevention. For e.g., the javelin thrower with incorrect biomechanics will not only have a shorter throw than he or she could have but is also more prone to injury (Muybridge, 1984).

Assessment techniques help us to prevent injury as well as in rehabilitation management. For e.g., selection of the running shoe according to the foot type and the requirement of the sport, selection of the racquet according to weight, size and grip as per the requirement of specific sport, variation in measurement of seat height, seat type, bar reach drop in cyclists (Muybridge, 1984).

Sports equipment and playing surfaces (Brukner and Khan, 2007)

Suitable equipment:

The sports clinician must be able to assess and advise the athletes the type of suitable equipment required for injury prevention. Sports Ergonomics helps us in designing and assessing various equipments required in sports like helmets, running shoes, spikes, football boots, ski boots, etc.

Shoes: the optimum shoe for a runner is one that matches the runner's specific mechanical features. The first part to be considered is the heel counter. The upper rear part of the shoe that is made up of rigid, firm plastic to assist in rear foot stability allows easy movement of the foot flexing at toe off.

Mid soles are usually made up of EVA which is light and good shock absorber. The midsole, which house the more complex shock absorbing material such as gel pads and air bladders,

should be used appropriately firm or soft depending on the mechanics and weight of the individual.

Foot wears are designed according to specific requirement of a sport like ankle stability, mobility, comfort or to reduce the slipperiness.

Racquets: There are a number of ways of altering the racquet to reduce the shock at impact and lessen the force transmitted to the player's arm. This can be done by lowering string tension, increasing flexibility of the racquet, increasing the size of a racquet head, increasing the weight and grip size.

Appropriate surfaces: The surface on which sports persons play is under the spotlight as it may be a major contributor to injury risk through excessive shoe surface traction. To prevent all possible injuries, it is important to consider playing surface hardness because of its association with overuse injuries such as stress fractures, shin pain etc. The ergonomic designing or studies help us on a sound understanding of issues such as the current trends and practice within individual sports and prevention of injuries. (Brukner and Khan, 2007)

Ergonomics of protective clothing: The influence of clothing is affected by various factors that include insulation for protection against cold and heat, vapour permeability or capacity for heat loss, air permeability, vapour resistance and protection from penetration of pollutants.

For e.g., loose fitting clothes often used in hot climates to keep the microclimate next to the skin cool. Tightly fitting clothes are preferable for enhancing aerodynamic properties of the body in cycling, sprinting and down skiing.

A full body suit or waist to ankle fastskin suit is used in swimmers in order to gain reduction in passive drag, lower energy cost and a greater distance per stroke.

Motor racing suits need to offer cooling as well as fire proofing because of the heat stress and risk of fire involved. Whereas wet suits for aquatic sports enable users to tolerate sustain periods of emersion in cold waters.

Sports brassieres have replaced the conventional fashion bras for females competing in track and field events, road running and games such as football, squash, running and tennis. (Dimitrov, 2010)

Protective equipment: They are designed to shield various parts of the body against injury interfering with sporting activity. Protective equipments commonly worn includes: mouth guards in collision sports, shoulder pads in rugby, chest, forearm and groin protectors in ice hockey, knee pads when playing on artificial surfaces. It is important that protective equipment fits correctly. They provide a psychological benefit by increasing a player's confidence (Brukner and Khan, 2007).

Sports Ergonomics innovations are not only benefitting athletes and amateurs of all ages to be able to use monitoring and feedback devices for physical and mental motivation but also provide important insight into how they can improve the performance of the athlete. Sports Ergonomics, thus, helps us in building the foundation for a successful future of the sports industry.

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