



Yves Vanlandewijck, PhD
*Sport Science Committee Chairperson,
International Paralympic Committee*

Sport science in the Paralympic movement

INTRODUCTION

The International Paralympic Committee (IPC) is the international governing body of sports for athletes with disabilities and acts as the International Federation for 12 sports. The IPC supervises and coordinates the Paralympic Summer and Winter Games and other multidisability competitions, such as the World Championships. The IPC also supports the recruitment and development of local, national, and international athletes at all performance levels.

The vision of the IPC is “to enable Paralympic athletes to achieve sporting excellence and inspire and excite the world.” This vision highlights the road to sporting excellence—the development of all athletes from initiation to elite levels of performance. In this guest editorial, the challenges to sport science are outlined on a continuum, with education and rehabilitation at one end and competition and elite-level excellence at the other.

PARTICIPATION: THE FIRST PREREQUISITE FOR SPORTING EXCELLENCE

For many people with a disability, participating in the Paralympic Games is simply not possible. People may dream of and aspire to reaching that elite level of athletic competition, but the hard work, dedication, talent, and luck required make it an unrealistic target for most. However, to dream is a great and powerful thing and some people *will* make it. All of today’s Paralympic athletes started somewhere: in the back garden with family and friends, at school with peers and teachers, or in local sports clubs [1]. In this section, I will explore rehabilitation and education as origins of athletic careers.

For many potential athletes, rehabilitation might add a new dimension to their active lifestyles. The question is, however, whether potential athletes at discharge from the rehabilitation center are emotionally and physically





International Paralympic Committee

prepared for this new dimension. In many cases, unfortunately, the answer is “no.” Taking the International Classification of Functioning, Disability, and Health model of the World Health Organization as a frame of reference [2], physiotherapy in 2006 could be called old-fashioned because it focuses mainly on function restoration rather than on participation. A recent cohort study of eight spinal cord injury (SCI) units in the Netherlands opened the door to in-depth discussion of rehabilitation outcomes; i.e., the level of physical fitness and wheelchair-handling proficiency of people with SCI leaving the rehabilitation center [3]. Both components will greatly influence an individual’s social range of action and therefore quality of life. Furthermore, a poor physical fitness level is obviously not the best starting point on the road to sporting excellence.

Studies of the factors influencing the participation of individuals with disabilities in sports clearly indicate that friends and peers with disabilities are much more influential as initial and continuing socialization agents than are rehabilitation therapists [4]. Therefore, rehabilitation centers should include

appropriate strategies in the rehabilitation program that encourage people with disabilities to participate in sports and leisure activities. Furthermore, education programs for rehabilitation therapists should be “participation”-oriented without minimizing the importance of optimal function restoration.

The second approach to recruitment of potential athletes is through the physical education systems. Since the 1970s, children with disabilities have been gradually migrating from noninclusive to inclusive educational environments; this phenomena has been especially apparent in the United States and many European countries. Unfortunately, inclusion of children with disabilities in general physical education settings does not always work, often because general physical educators may not be willing to take on the challenge of working with children with disabilities [5]. The major cause of this reluctance is reported to be the lack of training of general physical education teachers. The outcome for the child with disabilities, therefore, is dramatic. Not being a



Yves Vanlandewijck

functional member of the class or an active participant in many activities not only has a tremendous emotional effect on the child but also denies him or her access to activity programs essential for personal development in the broadest sense. Two strategies are recommended for avoiding this situation: (1) the use of an individualized education program that places children with disabilities in their least restrictive environment [6] and (2) the implementation of adaptive teaching strategies in all levels of physical education programs. If given the opportunity to be exposed to many activity programs, children can develop to their maximum sporting potential, perhaps leading to sporting excellence if they have the talent and determination.



SPORTING EXCELLENCE: CONTRIBUTION OF SPORT SCIENCE

Regarding sporting excellence of athletes with disabilities, sport scientists are challenged from multiple directions. The most important challenges include the (1) development of an evidence-based sport-specific classification system, (2) understanding of the causal mechanisms of sport injuries, (3) implementation of a comprehensive sport counseling system, (4) understanding of disability-specific responses to exercise and their effect on training strategies, and (5) understanding of the effect of

“boosting” and the consequent implementation of an antidoping education program.

Classification is simply an organizational structure that creates fair competition. Not unlike wrestling, boxing, and weightlifting, in which athletes are categorized by weight classes, athletes with disabilities are grouped in classes defined by the degree of function presented by the disability. Traditionally, athletes have belonged to six different disability groups in the Paralympic movement: amputation, cerebral palsy, visual impairment, SCI, intellectual disability, and those who do not fit in the aforementioned groups (officially known as *les autres*).

International classifiers define functional classification in disability sport as “the ordering of competitors into classes on the basis of their performance potential, based on the relationship between impairment and sport activity.” The purpose of classification is “to minimize the influence of impairments on sport outcome.” Following these statements, the classification criteria should be based on the relationship between the functional potential of the athlete and the determinants of a sport-specific performance. For example, for athletes with intellectual disabilities, use of only a general intelligence-quotient-based classification system would not lead to fair competition. Rather, the main question should be, How will the level of intellectual disability influence the capacity of the individual to play, for instance, standing basketball?

In 2006, classification in disability sport is not evidence-based. The determinants of sport-specific performance are poorly understood, and moreover, the causal relationship between sport-specific determinants and sport outcomes has not been proven. The sport proficiency model developed by the IPC Sport Science Committee demonstrates the complexity of the research question [7]. According to this model, achievement of elite performance in sports requires the transfer of physical potential, the firm execution of fundamental skills, and the ability to apply learning across different contexts into sport-specific, high-standard game or race situations. Disciplined practice and a sound athletic profile with a performance-driven attitude and personality will improve this acquisition process and help individual athletes perform to their maximum potential. Environmental prerequisites, such as optimized training quality and access to training and competition facilities, will also facilitate this process.

Clearly, only a holistic approach that controls all determinants of sport proficiency will lead to an evidence-based classification of athletes with disabilities. This approach is multidisciplinary and highly sport- and/or disability-specific and therefore warrants international cooperation between research teams.

Despite the growing awareness and popularity of sports for persons with disabilities, a relative paucity still exists in published research on the injury patterns and risk factors for injury among elite athletes with disabilities.

Although some types of injuries might be predicted based on the sporting discipline, the equip-

ment modifications (e.g., sledges) required for adaptation of a sport for Paralympic competition may expose these elite athletes to mechanisms of injury that are unique to disability sport. Therefore, the IPC Sport Science Committee, in recognition of the potentially devastating effect of injuries on elite athletes with disabilities, embarked on a long-term prospective injury-surveillance project designed to better characterize the risk factors for injury associated with Paralympic disciplines.

Data collected during the Salt Lake 2002 Winter Paralympics suggest that Paralympic winter sports are inherently dangerous—particularly Alpine skiing and ice-sledge hockey [8]. An overall injury rate in excess of 1 in 10 athletes in these disciplines was reported. Seventy-seven percent of all recorded injuries during the 2002 Winter Paralympics were caused by an acute traumatic event. This number is similar to the proportion of acute traumatic injuries seen during the Salt Lake 2002 Winter Olympics and roughly opposite to the proportion of acute versus overuse injuries calculated during the Sydney 2000 Summer Olympics.*

To address the increased prevalence of overuse injuries (repetitive strain injuries) in disability sport, researchers are studying the specific demands of each sport. Much progress has been made in recent years toward an understanding of repetitive strain injuries in wheelchair sports. Findings indicate that specific characteristics of the propulsion stroke are



*Crichton K. Sydney 2000 Games Polyclinic Report, unpublished observations.

linked to specific injuries [9]. These same propulsion-stroke characteristics likely can be modified through wheelchair setup and training. The reduction of injurious biomechanics offers hope for the prevention of repetitive strain injuries in wheelchair sports. In many other sports for persons with disabilities, however, this kind of fundamental research is still in its infancy.

Sport counseling is an interactive process among sport scientists, trainers/coaches, and elite athletes that aims to optimize the athletes' sport potential and maximize their performance. In some countries, sport counseling programs may be called "high-performance management" or "sport science and sport medicine support programs." For clarity, the term "sport counseling" is used in this article.



Sport counseling includes, but is not necessarily restricted to, fitness and training program development, skill development, performance strategy development, nutritional counseling, counseling for mental preparation, and mental health interventions, including psychological counseling. Part of the counseling process is the gathering of information; this is known as technical screening and includes the monitoring and assessment of skills, fitness, and nutritional states. Technical screening, however, is easier said than done. A few examples will clarify the complexity of disability sport counseling.

For a cyclist with spastic diplegia (cerebral palsy), finding the most economic pedaling strategy is extremely challenging. To give the most appropriate

feedback, the counselor needs insight into the force generation pattern of the cyclist and the metabolic cost under different external conditions (speed, slope, air drag) and with different gears. Furthermore, fatigue can significantly alter the response to exercise. For some technical events such as shot put, analyses are often restricted to two dimensions and are compared with the performance models of nondisabled athletes. Where reference to nondisabled sports is appropriate, the counselor needs a three-dimensional analysis to assess all determinants of shot put performance [10].



To extend the knowledge base for disability sport counseling, the IPC Sport Science Committee is establishing an international cooperation between sport counseling centers of excellence aimed at developing standardized protocols for athlete assessment and is implementing multidisciplinary athlete surveillance. This international cooperation will also establish a normative database and international guidelines for athlete surveillance.

Disability-specific responses to exercise have been intensively studied in the past decades. With inactivity as a result of paralysis, such as in SCI, the heart becomes less efficient; i.e., it has to compensate for a diminished ejection (stroke volume) with an increased contraction frequency. In addition to experiencing reduced cardiac efficiency, persons with SCI experience decreased sympathetic activity and venous return. When compared with nondisabled persons, persons with SCI exhibited circulatory hypokinesia, an approximately 68 percent reduction in cardiac output during maximal exercise [11].

Cardiovascular training can increase cardiac output by improving the efficiency of the circulatory system. For individuals with SCI in a clinical environment, this training is usually done through functional electric stimulation (FES) of the lower limbs. In a sport environment, however, no techniques are available today that are guaranteed to positively affect cardiovascular function, especially in persons with high-level SCI, such as those with tetraplegia. A 10-year follow-up of elite wheelchair rugby players with tetraplegia indicated significant improvement in performance on a 12-minute Cooper test and in power output on a maximum exercise test on a treadmill, without any changes in maximum oxygen uptake [12]. This improved performance seemed to be based on a combined optimization of equipment and interface and peripheral adaptation to exercise.

In addition to reduced cardiac output, athletes with SCI sweat very little, if at all, below the lesion level. As a result, heat loss via evaporation, which is the main mechanism of heat dissipation during exercise, is reduced. Especially in individuals with lesions above the sixth thoracic (T6) vertebra, this reduced heat loss will affect their ability to maintain steady cardiac output over time with continuous exercise [13].

The situation just described is one example of a specific metabolic response to exercise. Given the medical heterogeneity of potential athletes in disability sport, extra attention must be focused on exercise management for people with chronic diseases and disabilities. Especially with respect to

aerobic and anaerobic capacity enhancement, trainers and coaches are searching for new disability-specific training strategies.

Like nondisabled athletes, athletes with disabilities must obey the laws of the World Anti-Doping Agency. Antidoping, however, has a disability-specific dimension. For example, individuals with SCI at lesion levels above T6 demonstrate a unique reflex syndrome called autonomic dysreflexia. This reflex occurs spontaneously and results in a sympathetic discharge that elevates arterial blood pressure and associated cardiovascular responses, which can enhance physical performance.

Athletes with high-level SCI who compete in wheelchair sports can voluntarily induce autonomic dysreflexia before or during an event to enhance their performance. Research has demonstrated that this practice, commonly referred to as “boosting,” improves middle-distance wheelchair racing performance by approximately 10 percent in elite athletes with high-level SCI [14]. This study also indicated that boosting elevated the arterial blood pressure during a wheelchair race to significantly higher, and in some

cases life-threatening, levels compared with the “unboosted” state. To ensure that all athletes compete safely on an equitable basis, the IPC Anti-Doping Code prohibits boosting and considers it an illegal and unethical practice.

Another example of the disability-specific dimension of antidoping is “technical boosting.” Technical boosting refers to an athlete’s use of advanced technical equipment, such as wheelchairs made of light materials. Technical boosting could also



be extended to concepts such as the “osseointegrated” prosthesis, in which a threaded titanium implant is inserted in the middiaphysis of the tibia or femur so that, once fully osseointegrated, it acts as an attachment site for a lower-limb external prosthesis. From a biomechanical viewpoint, this kind of interface obviously benefits performance compared with the classical technique that relies on a prosthetic limb that interfaces with the residual limb via a well-fitting socket. However, the use of osseointegrated prostheses in disability sport is not only a question of ergonomics but also of sport ethics. The ethical issue resides in the differential availability of these products in developing countries versus wealthier industrialized countries.

In conclusion, the IPC’s challenges from a sport-science perspective are multifactorial and multidisciplinary. In this editorial, I have provided insight into key areas where more research is needed, such as sociology, ethics, ergonomics, exercise physiology, biomechanics, and sports medicine. Clearly, relevant solutions will be based on multidisciplinary research as a result of cooperation between international governing bodies, such as the IPC and international federations for disability sports, and international networks of researchers. Close cooperation with researchers from nondisabled sport is warranted, since basic knowledge and theoretical models can be transferred without major adaptations to disability sport. A promising and historical step in this cooperation will be the first Convention on Science, Education, and Medicine in Sport, to be held in 2008 in China. This convention is a collaborative effort of the IPC, International Olympic Committee, International Council on Sport Science and Physical Education, and International Federation on Sports Medicine.

REFERENCES

1. Downs P. Participation towards the Paralympic Games. In: Paralympic Games from 1960 to 2004. Athens (Greece): ATHENS 2004 Organising Committee for the Olympic Games; 2004. p. 270. Available from: http://www.paralympic.org/release/Main_Sections_Menu/Education/ATHENS_Education_Material.pdf
2. World Health Organization. International classification of functioning, disability and health. Geneva (Switzerland): World Health Organization; 2001.
3. Van der Woude LH, Janssen TW, Veeger DJ. Background on the 3rd International Congress “Restoration of (wheeled) mobility in SCI rehabilitation”: State of the art III. *J Rehabil Res Dev*. 2005;42(3 Suppl 1):vii–xiii. [\[PMID: 16195957\]](#)
4. Wu SK, Williams T. Factors influencing sport participation among athletes with spinal cord injury. *Med Sci Sports Exerc*. 2001;33(2):177–82. [\[PMID: 11224802\]](#)
5. Block ME. Did we jump on the wrong bandwagon? Problems with inclusion in physical education. *Palaestra*. 1999;15:30–56.
6. Sherrill C. Adapted physical activity, recreation and sport: Crossdisciplinary and lifespan. Boston (MA): McGraw-Hill; 1998. p. 706.
7. General Group. Eligibility of athletes with intellectual disabilities in IPC sanctioned events: Report to the Governing Board of the IPC; 2006 Jun; Lausanne, Switzerland. Bonn (Germany): IPC Sport Science Committee; 2006. p. 11–16.
8. Webborn N, Willick S, Reeser JC. Injuries among disabled athletes during the 2002 Winter Paralympic Games. *Med Sci Sports Exerc*. 2006;38(5):811–15. [\[PMID: 16672831\]](#)
9. Boninger ML, Cooper RA. Repetitive strain injuries in manual wheelchair users. In: Van der Woude LH, Hopman MT, Van Kamenade CH, editors. Biomedical aspects of manual wheelchair propulsion: The state of the art II. Amsterdam (the Netherlands): IOS Press; 1999.
10. Chow JW, Chae WS, Crawford MJ. Kinematic analysis of shot-putting performed by wheelchair athletes of different medical classes. *J Sport Sci*. 2000;18(5):321–30. [\[PMID: 10855678\]](#)
11. Hoffman MD. Cardiorespiratory fitness and training in quadriplegics and paraplegics. *Sports Med*. 1986; 3(5):312–30. [\[PMID: 3529281\]](#)
12. Van de Vliet P, Vanlandewijck YV. Performance enhancement through sport science: The case of Belgian Wheelchair Rugby. In: Electronic Proceedings of the VISTA 2003 Conference; 2003 Sep 11–14; Bollnäs, Sweden. Bollnäs (Sweden): Swedish Development Center for Disability Sport; 2003.
13. Hopman MT, Oeseburg B, Binkhorst RA. Cardiovascular responses in persons with paraplegia to prolonged

- arm exercise and thermal stress. *Med Sci Sports Exerc.* 1993;25(5):577–83. [\[PMID: 8492685\]](#)
14. Burnham R, Wheeler G, Bhambhani Y, Belanger M. Intentional induction of autonomic dysreflexia among quadriplegic athletes for performance enhancement: Efficacy, safety, and mechanism of action. *Clin J Sport Med.* 1994;4(1):1–10.

Yves Vanlandewijck, PhD

Faculty of Kinesiology and Rehabilitation Sciences,
Katholieke Universiteit Leuven, Leuven, Belgium;
Sport Science Committee Chairperson, IPC

Email: yves.vanlandewijck@faber.kuleuven.be

DOI: 10.1682/JRRD.2006.07.0078