10. Tidball JG, Wehling-Henricks M. Macrophages promote muscle membrane repair and muscle fibre growth and regeneration during modified muscle loading in mice *in vivo. J Physiol* 2007; 578(Pt 1): 327-336.
11. Shen W, Li Y, Tang Y, Cummins J, Huard J. NS-398, a cyclooxygenase-2-specific inhibitor, delays skeletal muscle healing by decreasing regeneration and promoting fibrosis. *Am J Pathol* 2005; 167(4): 1105-1117.
12. Foster W, Li Y, Usas A, Somogyi G, Huard J. Gamma interferon as an antifibrosis agent in skeletal muscle. *J Orthop Res* 2003; 21(5): 798-804.
13. Fukushima K, Badlani N, Usas A, Riano F, Fu F, Huard J. The use of an antifibrosis agent to improve muscle recovery after laceration. *Am J Sports Med* 2001; 29(4): 394-402.
14. Jarvinen M, Lehto M, Sorvari T, Mikola A. Effect of some anti-inflammatory agents on the healing of ruptured muscle. an experimental study in rats. *Journal of Sports Traumatology and Related Research* 1992; 14: 19-28.
15. Kujala UM, Orava S, Jarvinen M. Hamstring injuries. Current trends in treatment and prevention. *Sports Med* 1997; 23(6): 397-404.

Talent identification in sport: Practices and issues

ROSA DU RANDT, *PhD*

Professor and Head, Department of Human Movement Science, Nelson Mandela Metropolitan University, Port Elizabeth

Sport is no different to other domains such as science, music and the arts, where the attainment of excellence is the primary goal of many individuals.[1] Expert performance is acknowledged by spectators and sponsors alike, but achievement of excellence is no easy feat as the gap between success and failure in elite competition continues to narrow and the weight of national pride and expectation continues to increase.[2] Consequently, the study of expertise in sport, together with the identification and development of future elite performers, has become a popular focus area within the sport sciences.[1]

A basic definition of talent identification (TI) encompasses the recognition of a natural endowment or ability of superior quality. But, identifying a talented athlete within sport is multifaceted and complex. Talent in sport is identified by characteristics that are at least partially genetically determined, affected by numerous environmental conditions and currently difficult to determine accurately.[3]

The disparity between practice and theory involved in TI has become apparent and, while researchers are currently closing this gap, the advent of gene mapping and the subsequent potential for gene testing and therapy have added a new dimension to this endeavour.

Systematic approaches to TI

Systematic TI is no new phenomenon. Several countries, in particular the former 'Eastern block' countries, have applied systematic TI since the 1960s and early 1970s with astounding results during the Olympics of 1972, 1976 and 1980. These successes were ascribed to their thorough TI processes adopted in the late 1960s.[4]

Western countries also initiated systematic TI programmes, albeit with their own unique variation and mostly without the associated political ideology. Australia was the first Western country to implement such a programme, the Sport Search Programme, in 1994.[5] South Africa, in an endeavour to find solutions for the disproportionate representation of the South African population in representative teams, commissioned research in the early nineties to investigate solutions to the problem.[6] An adapted version of the Australian sport search programme was subsequently applied in the late nineties, and follow-up sport-specific programmes involving selected national sport federations were planned, but all these efforts lost momentum with continuous changes in the national governance of sport.

Other countries such as the UK also adopted the Australian concept of TI and embarked on a systematic and organised approach. However, these systematic approaches to TI, although very inclusive, proved to be very expensive and the returns did not seem to justify the costs, especially for team sports. Subsequently, more focused approaches that rely on multidisciplinary inputs have been initiated with evidence of more success.[3]

Gene mapping and therapy for sports doping

The elucidation of the complete human genome with approximately 30 000 different genes has led to new possibilities, not only for the diagnosis and prevention of a wide variety of diseases, but also for the purpose of TI. Close to 200 genes, or loci linked to or associated with human performance and health-related fitness, have already been identified.[7] Testing such genes, some propose, can be a legitimate aspect of TI and training programme development – a valid adjunct to current physiological, biochemical and psychological testing.[8] Gene technology companies are already supplying testing kits for the purpose of identifying selected genes (e.g. www.gtg.com.au).

In addition, the knowledge of gene mapping may be used for the design of new therapeutics, including gene therapy, based on DNA sequence information. Gene therapy may not only be applied for the treatment of serious diseases, but also for less life-threatening situations or injuries such as sports injuries.[9] In addition, athletes may be able to use gene therapy to improve their bodies for better performance. Many genes with the potential to enhance athletic performance are available. The most relevant of these for performance enhancement are erythropoietin (EPO), growth factors, myostatin and endorphins.[9]

Gene therapy also opens the door for gene doping, a practice disapproved by both the International Olympic Committee … and the World Anti-Doping Agency.

Risks of gene doping and ethics involved in the detection thereof

A number of risks are associated with gene doping, especially where gene transfer vectors are produced in non-controlled laboratories.[9] Furthermore, the detection of gene doping is currently very difficult and evokes many ethical concerns.[10]

Conclusion

While the need for TI practices and the drive for countries to prove dominance at major international competitions remain, researchers are interrogating the scientific justification for current and past practices and are calling for more focused research in this area. For a more comprehensive evaluation of current practices see the academic review commissioned by Sport Scotland.[4] These endeavours to find more appropriate methods of TI will continue as long as the drive for success in the international arena persists. Although gene testing and gene therapy/doping have the potential to dominate TI in the future, the myriad of ethical issues and health risks of disreputable therapy practices may delay its impact.

References

1. Williams AM, Reilly T. Talent identification and development in soccer. *J Sports Sci* 2000; 18: 657- 667.
2. Davidson R. Editorial. *J Sports Sci* 2006; 24(8): 805.
3. Pearson DT, Naughton GA, Torode M. Predictability of physiological testing and the role of maturation in talent identification for adolescent team sports. *J Sci Med Sport* 2006; 9(4): 277-287.
4. Wolstencroft E, ed. *Talent Identification and Development: An Academic Review* (A report for Sportscotland by the University of Edinburgh). Edinburgh: Sportscotland, 2002. (Online.) http://www.sportscotland.org.uk/ChannelNavigation/Resource+Library/

Publications/Talent+Identification+and+Development+Programme.htm (accessed 30 March 2008).

5. Hoare D. The Australian national talent search programme. *Coaching Focus* 1996; 31: 3-4.

6. Du Randt R, Headley N, Loots JM, Potgieter JR, De Ridder JH, Van der Walt TSP. An updated contract research report conducted on behalf of the Federation for Movement and Leisure Sciences for the Department of National Education, South Africa. An unpublished document of the University of Port Elizabeth (now Nelson Mandela Metropolitan University), 1993.

7. Rakinen T, Bray MS, Hagberg JM, *et al.* The human gene map for performance and health-related fitness phenotypes: the 2005 update. *Med Sci Sports Exerc* 2006; 38(11): 1863-1888.

8. Human Genetics Commission of Australia (HGSA) Position Statement. Genetic testing and sport performance, 2007. (Online.) http://hgsa.com.au/images//Attachments/HGSAPositionstatementonGeneticTestingandSportPerfo%E2%80%A6.pdf (accessed 23 March 2008).

9. Haisma, HJ, De Hon O, Sollie P, Vorstenbosch J. *Gene Doping.* Capelle aan den Ijssel: Netherlands Centre for Doping Affairs, 2004. (Online.) http//www.dopingautoriteit.nl/campagnes/publicaties (accessed 22 March 2008).

10. Miah A, Rich E. Genetic tests for ability?: Talent identification and the value of an open future. *Sport, Education and Society* 2006; 11(3): 259-273. (Online.) www.andymiah.net/writing.html (accessed 10 March 2008).

Further reading

Foddy B. The ethics of genetic testing in sport. *International Sport Med Journal* 2006; 7(3): 216-224. (Online.) http://www.ismj.com (accessed 10 February 2008).

McGregor B. The use of gene-based technologies for talent identification in high-performance sport. Unpublished document of Bond University, Robina, Queensland, Australia. (Online.) www.sportecoach.com.au/downloads/the use of gene-based technologies for talent identification.doc (accessed 28 March 2008).

Moore C, Khoury MJ. ACTN3 variants and athletic performance. (Online.) http://www.cdc.gov/genomics/hugenet/ejournal/ACTN3.htm (accessed 10 December 2007).

Respiratory muscle fatigue during exercise

ELMARIE TERBLANCHE, *PhD*
Professor, Department of Sport Science, Stellenbosch University

The traditional perspective is that the pulmonary system has a large reserve capacity that is more than capable of meeting the demands of very heavy physical exercise in healthy individuals. It is also postulated that the only exception to the latter is the exercise-induced arterial hypoxaemia that is observed in some highly trained individuals at maximal exercise. However, several studies have demonstrated that respiratory muscles (RM) can fatigue during prolonged and maximal exercise, and this may have significant effects on athletic performance. RM fatigue is usually quantified as a reduction in RM strength from resting values, where RM strength is indirectly estimated through maximal inspiratory pressure (MIP).

The metabolic cost of breathing

At rest, breathing is primarily an inspiratory activity, while expiration is a passive process. Thus, the oxygen cost of breathing at rest is only about 2% of total body oxygen consumption. During exercise, when expiration also becomes an active process, the oxygen cost of breathing increases from 3 - 5% during moderate exercise to 10% during strenuous exercise. In highly trained individuals the latter may rise to 15 - 16% of VO_{2max}.[1,2] The implication of this greater oxygen cost of breathing is that the respiratory muscles require a greater proportion of the cardiac output with an increase in exercise intensity, thus leaving a smaller percentage of cardiac output available to the active limb locomotor muscles. This may significantly contribute to the onset of skeletal muscle fatigue.

Do respiratory muscles fatigue during exercise?

Numerous studies have shown that the respiratory muscles are subject to fatigue in a similar fashion to limb locomotor muscles. Evidence for this has been obtained during laboratory exercise tests, as well as during exercise in the field. Ozkaplan *et al.*[3] found that MIP was significantly reduced in moderately trained men and women after an incremental exercise test to exhaustion. McConnell *et al.*[4] demonstrated that an incremental shuttle-run to fatigue (exercise lasting 10 - 15 minutes) leads to a significant reduction in MIP (8.2%), and thus RM fatigue in moderately trained men. Lomax and McConnell[5] demonstrated a significant reduction (29%) in MIP after a single 200 meter swim in 7 competitive swimmers. Chevrolet *et al.*[6] found significantly lower MIP values in both marathon and half-marathon runners after a race, while Ker and Schultz[7] observed similar results in athletes after an ultra-marathon event.

Although individuals with the weakest inspiratory muscles experience the greatest amount of RM fatigue, high levels of fitness do not protect individuals from developing RM fatigue. Thus, even athletes with above-average respiratory muscle strength and endurance experience RM fatigue. The magnitude of RM fatigue is directly related to the duration and intensity of exercise; most researchers agree that sustained exercise at intensities higher than 80 - 85% of VO_{2max} consistently cause fatigue of the diaphragm at the end of exercise.[8]

Does RM fatigue affect exercise performance?

Given the high demand for oxygen and blood flow by the respiratory muscles during whole-body endurance-type exercise, it is not surprising that exercise performance is impaired during high-intensity exercise. Harms *et al.*[9] found that with respiratory muscle unloading, well-trained cyclists exercised for 1.3 ± 2.0 min longer (an increase of 14.4%) during a constant workload test at 90% VO_{2max} than during control conditions. On the other hand, exercise time significantly decreased by 1.0 ± 0.8 min (15.1%) with respiratory loading compared with control conditions. Therefore, decreasing the work of breathing led to a significant improvement in time to exhaustion. Furthermore, respiratory muscle unloading also resulted in reduced VO_2, a decrease in minute ventilation, and reduced perceptions of respiratory and limb discomfort. These findings were confirmed by Babcock *et al.*,[10] who demonstrated that mechanical unloading of the respiratory muscles during heavy sustained exercise prevented diaphragm fatigue.

Does RM training affect exercise performance?

A number of studies investigated the effects of resistive loading on RM strength and have reported increases in MIP of 8 - 45%.[8] Whether this improvement in RM strength translates to an increase in exercise performance, is somewhat controversial. McConnell and Romer[11] analysed all the RM training studies and concluded that weak experimental designs, insufficient statistical power and inappropriate performance tests could explain the negative findings of earlier studies. Studies that have shown statistically significant improvements in performance utilised fixed work rate tests or time trial-type performance measures. In these cases, performance improvements between 24% and 50% (for fixed work rate tests) and between 1.8% and 3.5% (for time trial tests) were reported.

The magnitude of the observed training effects may be sufficient to provide athletes with a winning edge. Thus, for athletes constantly seeking for ways to enhance their performance, RM training may provide a legitimate ergogenic aid.

In conclusion

- Respiratory muscles of healthy individuals do fatigue during whole-body endurance exercise.
- The higher cost of breathing during exercise compromises blood flow to active limb locomotor muscles.
- Respiratory muscle fatigue can impair exercise performance in trained individuals.
- A number of studies show that respiratory muscle training may improve exercise tolerance and could thus have ergogenic benefits in trained individuals.

References

1. Aaron EA, Seow KC, Johnson BD, Dempsey JA. Oxygen cost of exercise hyperpnea: implications for performance. *J Appl Physiol* 1992; 72: 1818-1825.
2. Harms CA, Wetter T, McClaran SR, *et al.* Effect of respiratory muscle work on cardiac output and its distribution during maximal exercise. *J Appl Physiol* 1998; 85: 609-618.
3. Ozkaplan A, Rhodes EC, Sheel AW. A comparison of inspiratory muscle fatigue following maximal exercise in moderately trained male and females. *Eur J Appl Physiol* 2005; 95: 52-56.
4. McConnell AK, Caine MP, Sharpe GR. Inspiratory muscle fatigue following running to volitional fatigue: the influence of baseline strength. *Int J Sport Med* 1997; 18: 169 -173.
5. Lomax ME, McConnell AK. Inspiratory muscle fatigue in swimmers after a single 200m swim. *J Sports Sci* 2003; 21: 659-664.
6. Chevrolet J, Tchopp J, Blanc Y, Rochat T, Junod AF. Alterations in inspiratory and leg muscle force and recovery pattern after a marathon. *Med Sci Sports Exerc* 1992; 25(4): 501-507.
7. Ker JA, Schultz CM. Respiratory muscle fatigue after an ultra-marathon measured as inspiratory task failure. *Int J Sports Med* 1996; 17(7): 493-496.
8. Sheel AW. Respiratory muscle training in healthy individuals. Physiological rationale and implications for exercise performance. *Sports Med* 2002; 32(9): 567-581.
9. Harms CA, Wetter TJ, St Croix CM, Pegelow DF, Dempsey JA. Effects of respiratory muscle work on exercise performance. *J Appl Physiol* 2000; 89: 131-138.
10. Babcock MA, Pegelow DF, Harms CA, Dempsey JA. Effects of respiratory muscle unloading on exercise-induced diaphragm fatigue. *J Appl Physiol* 2002; 93: 201-206.
11. McConnell AK, Romer LM. Respiratory muscle training in healthy humans: resolving the controversy. *Int J Sports Med* 2004; 25: 284-293.