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THE USE OF GENE-BASED TECHNOLOGIES FOR TALENT IDENTIFICATION IN HIGH-PERFORMANCE SPORT

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Introduction

Talent identification (TID) and development has become a vital component of many sport programmes (Falk et al. 2004). This is particularly true in Australia where significant resources have gone into developing a national *Talent Search* program that is implemented through the Australian Institute of Sport (AIS). The significance of TID in this country probably stems from greater competition between sports for talented individuals (Hoare and Warr, 2000) within a relatively small population base compared to sporting superpowers such as the USA, Russia, Germany and more recently, China.

The literature reviewed indicates a high success rate of TID within sports that are individual and repetitive with specific anthropometric and physiological requirements such as rowing, weightlifting, cycling, canoeing and athletics (Hoare and Warr 2000, Australian Law Reform Commission 1996). However the use of TID within sports requiring more decision-making and “game sense” requires further investigation before accurate prediction models can be accepted (Falk et al. 2004, Hoare and Warr, 2000, Lidor et al. 2005, Pienaar et al. 1998, Reilly et al. 2000, Reilly and Gilbourne 2003).

The use of gene-based technologies as a TID method is beginning to receive greater attention as knowledge about the human gene map (Perusse et al. 2003) becomes more apparent. This introduces an ethical dilemma and has re-ignited the age-old debate of nature versus nurture.

Current talent identification methods

TID is not a new concept with initial research into “giftedness” beginning in the 1970’s (Hohmann and Seidel 2003). These authors cite a report that details TID at its most primitive:

> “The first talent identification test I saw was at school. When classes marched into the pool the teacher stood by the door, looking down at the ground and pulling various people out of the line – the ones who walked with the feet splayed out. He made them concentrate on breaststroke. That school always did well in breaststroke events” (p11).

Since the 1970’s two models have been formulated for the detection of talent. A retrospective model involves interviewing elite athletes in order to “look backwards” at the steps that were taken to achieve athletic excellence, whereas prospective studies examine the same individual over time (Falk et al. 2004). Although the former model has revealed some interesting information about the *habits* of elite performers, many coaches and athletes have made the mistake of copying the champions in every aspect to replicate their success.

More recently, TID studies have revealed that success (in team sports especially) is the result of a complex interaction of variables that are not fully understood (Falk et al, 2004, Hoare and Warr, 2000, Reilly et al. 2000). Therefore copying the champions certainly neglects the individual aspects that contribute to talent.

Falk et al. (2004) emphasise the importance of early talent detection and describe three aspects of TID - physiological, psychological and sociological. Early TID methods are designed to identify those individuals (children) with favourable physiological traits (genetics) for a particular sport. Hoare and Warr (2000) state that this method is suited to individual, repetitive sports wherein success depends on anthropometric and physiological attributes. Examples cited include weightlifting, cycling, canoeing, athletics and rowing.

Swimming is another sport that encourages early detection of potential talent through identifying those with certain physical characteristics. Ralph Richards (1999) outlines that morphology (mostly ectomorphic) will influence factors such as lift and drag. The same author advocates that TID should commence between 10 and 12 years of age in order to teach the technical aspect of swimming. However identifying genetically gifted individuals is not enough to guarantee success. Richards (1999) also mentions that a talented swimmer will possess a “feel” for the water that is the result of a heightened sense of balance and body awareness.

Rowing is another sport that aims to take advantage of physiological and anthropometric screening. The AIS have developed a program called “breaking the drought” which aims to attract potential rowers from schools in order to address Australia’s poor record in heavyweight single sculls (http://www.ausport.gov.au). The emphasis on screening for structural characteristics in these individual sports is explained by Patel and Greydanus (2002) who cite the following characteristics as having a large genetic influence:

- Height, length of arms
- Muscle size, strength and muscle fibre composition
- Heart size and resting heart rate
- Lung size and volume
- Flexibility of joints.

The same authors (Patel and Greydanus, 2002) also state that genetics affects “the response of the cardiopulmonary system to exercise training” (p251). This view is supported by MacArthur and North (2005) who cite research stating that genes are responsible for 30% of baseline exercise heart rate and 27% of heart rate variance in response to training.

Therefore it appears that TID in the closed sports previously mentioned is useful for not only identifying individuals with optimal physiology and morphology, but can also detect those individuals with a greater capacity to respond and adapt to training.

However can the same TID principles be applied to team sports? Research reviewed examined soccer (Hoare and Warr, 2000, Reilly et al. 2000, Reilly and Gilbourne 2003), water polo (Falk et al. 2004) and rugby union (Pienaar et al. 1998). Not surprisingly, the use of genetically determined qualities (physiology and morphology) did not play such a major role in the early detection of elite performers. Other factors contributing to success in these sports include game knowledge and game sense (Hoare and Warr 2000), team coherence (Reilly et al. 2000), status of maturity (Pienaar et al. 1998), anticipation and decision making (Falk et al. 2004).

Therefore the interaction between physiological, psychological and sociological factors mentioned by Falk et al. (2004) appears even more important for TID in team sports. This is also supported by Davids (2001) who comments that performance cannot be determined in a mechanistic or formulaic manner. The same author also feels that success, even in a closed sport such as running, requires elements of mental toughness, tactical astuteness and motivation. Therefore psychological profiling appears to be an important part of TID.
This is reflected in the AIS talent search program where identifying “hard eggs” that possess mental fortitude versus “soft eggs” who lack persistence helps address these psychological aspects (http://www.ausport.gov.au).

The success of TID in team sports appears to be greater when tests for open skills such as decision-making and “game intelligence” are incorporated. Falk et al. (2004) examined 14-15 year old water-polo players and found they were able to predict 67% of players who would go on to make the junior national team. They found that “the selected players were better not only on the technical tests, but also in the game intelligence evaluation” (p351). Lidor et al. (2005) examined 12-13 year old handball players and found that an open sport-specific skill test was the only reliable predictor of players to make the junior national team 2-3 years later. Interestingly, the physical tests only predicted 23% of junior national team members, whereas the specific performance test was much higher at 50%.

Hoare and Warr (2000) recruited 15-19 year old females from different sports using a battery of anthropometric, physiological and skill tests. Of the 17 athletes chosen 10 went on to make Queensland zone teams and 2 went on to compete in the Australian National Women’s League. The authors did conclude that more weighting should be given to speed and acceleration and goalkeepers should undergo a specialised test. They also commented that there was a need for an objective test to measure game sense as many players were good athletes but lacked this game awareness.

Other studies to look at soccer include Reilly et al. (2000) and Reilly and Gilbourne (2003). The former study acknowledged the difficulty in successfully identifying talented youngsters due to the complex nature of the sport, and found that no single method can represent a player's physical capabilities. Therefore anthropometric and physiological data should be used to monitor young players rather than be used for selection. Reilly and Gilbourne (2003) cite a study by Manning et al. (2003) that reported a relationship between the ratio of 2^{nd} and 4^{th} digit length and soccer ability. This ratio is a supposed indicator of running speed, football ability and visuo-spatial perception. However it is noted that "the use of the ratio as a predictive tool remains unexplored" (p701).

Pienaar et al. (1998) were able to predict 88% of 10 year old boys with no rugby background who went on to gain selection in regional primary school teams. Tests used included physical, motor and anthropometric measurements. Importantly, the authors acknowledge that physical maturity should be assessed in TID programs to ensure that late-maturing children are not overlooked.

A closer examination of the above studies reveals a lack of longitudinal analysis in TID research. The published data does look promising however the time-frames for follow-up in these studies are relatively short (not exceeding 3 years). There is certainly a need for more long-term studies to determine if TID programs can effectively identify elite adult performers at a young age.

The role of gene analysis for talent identification and sport

Hohmann and Seidel (2003) cite a quote by Hopkins (2001), “if you want your kids to be great athletes, marry a great athlete” (p12). This school of thought places a large emphasis on having the right gene structure in order to succeed at sport. On the other hand, a greater number of researchers conclude that it is a combination of numerous factors (including genetics and environment) that go towards creating an elite performer (Baker 2001, Davids 2001, MacArthur and North 2005, Patel and Greydanus 2002, Pitsiladis and Scott 2005, Reilly et al. 2000). The potential use of gene assessment for TID has unearthed the age-old debate of nature versus nurture.

Indeed some researchers are of the belief that a “sports gene” exists that can help predict talent from a very early age (Patel and Greydanus 2002). However this theory is certainly not plausible when looking at the work of Perusse et al. (2003) who, by the end of 2002, identified 90 different gene entries in their human gene-map for performance.

When considering the use of gene-based technologies for TID, one must consider the degree to which a physical ability is determined by genetic make-up. Aerobic performance and VO_2max commonly appears in the literature as a factor that is largely determined by genetics. Patel and Greydanus (2002) offer that 30-70% of an individual’s cardiac structures and response to cardiopulmonary exercise is genetically pre-determined.

MacArthur and North (2005) state that genes account for more than 40% of variance in oxygen uptake at the ventilatory threshold. Hohmann and Seidel (2003) explain that the percentage of VO_2 max attributed to genetics has shifted from 90% in the 1970's to approximately 50%.

Research into the angiotensin-converting enzyme (ACE) gene has revealed information about an individuals preference for endurance or power type events. Patel and Greydanus (2002) cite a number of studies that show an association between the ACE I allele and endurance capacity. In his article for the Medical Post, Chris Pritchard (1998) cites work done by Ron Trent showing that 30% of elite rowers possessed 2 copies of the ACE I allele, compared with 18% in the control group. Although initial work may be promising, the same researcher (Trent) admits that the contribution of genes to elite athletic performance may vary between 5-90% and feels that it is more likely to be closer to the lower end of this range (Australian Law Reform Commission 2003).

In terms of the overall contribution of genetics to performance, Hopkins (2001) feels that genetics account for half of an individual's performance and at least half of the variation in response to training. However the 50-50 view is not supported by Baker (2001) who cites the fact that height is approximately 80% genetically determined for this argument.

Looking at the debate and uncertainty surrounding the contribution of genes to performance, it appears that significantly more research needs to be conducted before conclusions can be drawn about the accuracy of genetics in TID.

Despite the fact that research into genetics is in its infancy, genetic screening is currently available for the ACTN3 gene that is expressed in fast-twitch muscle fibres. The company that performs this test claim that it can “provide an insight into the best event in which to compete in the sport of your choice, so that the individual can obtain the best results for their efforts” (pS17). The use of 1 gene as a guide for sport and event selection appears naïve given the complex interaction not only between genes, but between genetics and the environment. This is a view that does have support in the literature (Davids 2001, MacArthur and North 2005, Patel and Greydanus 2002, Pitsiladis and Scott 2005).

Genetic screening is also being used to individualise training programs to suit a person’s genotype. Dennis (2005) reports that the Manly Sea Eagles rugby league team have already DNA tested its players for 11 exercise-related genes. The team physiologist explains: “We don’t want a player running 100 kilometres a week if his genes say he’s more suited to 50 kilometres a week and doing more weights” (p260). Given that the human gene map for performance (Perusse et al. 2003) has identified 90 gene entries that influence performance, the identification of 11 genes would appear to provide limited information for program design.

Pitsiladis (2005) comments on this approach stating that the ability to run fast is more effectively measured with a stopwatch.

In terms of gene-analysis for TID, the above-mentioned team physiologist doubts that genetic screening will be used for player selection as such tests “don’t measure the passion that makes players great” (pS17). However AIS Assistant Director Peter Fricker feels that genetic screening of athletes will become as common as measuring height and weight and will be a consideration in determining which athletes gain access to resources provided by the AIS. This viewpoint leads to the ethical dilemma that is discussed in the following section.

The ethical dilemma

The use of gene-based technologies for TID poses an interesting ethical situation. The role of gene research is an important one in discovering new ways to treat various health conditions, however when the same technology is applied to sport the questions of “how” and “why” take on much greater significance. Will such an advancement only serve to further increase the chasm that exists in elite-level sport between the affluent nations with scientific funding, and those without? Or will this technology enable us to maximise sporting participation and success through guiding individuals towards endeavours to which they are more suited?

In an article written by Chris Pritchard (1998) AIS physiologist Allan Hahn believes genetic screening would “merely be an adjunct to the barrage of tests already conducted” (p 2). He also feels that such technology would help people get more enjoyment out of sport by participating in things that they are more suited to. AIS Assistant Director Peter Fricker feels that Australia will fall behind other nations if we do not embrace genetic screening of athletes (Australian Law Reform Commission, 1996).

MacArthur and North (2005) also feel that genetic screening may not only have a role to play in TID, but may revolutionise the entire concept. In particular, gene analysis may provide information about a child’s ability where a physiological pathway is difficult to measure and has a weak correlation with adult performance. That is, genetic TID could be used in areas where physiological testing is not a good predictor.

There is no doubt that a sport like swimming would be interested in genetic screening considering the emphasis that Ralph Richards (1999) places on morphology for high-level performance.

In 1996 the Australian Law Reform Commission (ALRC) report states that an athlete’s genetic profile will be a consideration in determining not only access to resources provided by institutions such as the AIS, but also in deciding who is accepted to compete in elite competitions.

This stance has significant legal implications given the financial rewards that now exist in elite level sport. The ALRC examined the Disability Discrimination Act 1992 and concluded that genetic testing would not contravene this act providing the tests were “sufficiently reliable and relevant to the skills and abilities required” (p 5).

The ALRC report also cites the Australian Sports Commission Act 1989 that allows the AIS to reasonably discriminate between persons on the basis of physical and physiological attributes in order to implement a Commonwealth program. By its nature, TID needs to be discriminatory in order to select the best performers. However it appears that it is *how* genetic information is used that is important in avoiding recourse by disgruntled athletes.

The privacy of genetic information is another issue worthy of discussion. Interestingly, the ALRC report found that though many organisations (including the AIS) are covered by the Privacy Act 1988, this legislation does not extend to cover state and local government organisations outside the ACT. Many organisations would be considered small businesses which enables them to hold genetic information about athletes as “employee records” which is not covered by the afore-mentioned Act. This is an area that needs clarification before genetic screening becomes “mainstream” and corporate governance should ensure that fair and equitable guidelines are formulated to protect athletes who undergo genetic screening.

Patel and Greydanus (2002) raise the issue of “gene farming” where people may seek out “athletic” gamete donors in order to produce athletic genotypes. The ramifications of this are significant in terms of the pressure that may be brought to bear on the sibling to perform at a high level due to their favourable genetic profile. The same authors (Patel and Greydanus, 2002) also question how information gleamed from genes should be used. For example, if a gene were identified that leads to an adverse outcome from brain injury, should these people be precluded from all contact sports? For youth sports especially, where does the balance lie between having a choice and protection from possible injury complications?

Another consideration is if a child is aware that they may be lacking genetic potential for a certain sport, will they be less likely to participate? This was the question raise by Bouchard et al. (1997) and is cited in Patel and Greydanus (2002). The ALRC (1996) also raise the concern of genetic screening limiting life choices of those who are identified as “elite” at a young age, while discouraging others from even trying. It is interesting to note that these opinions are in direct contrast to the opinion of Allan Hahn who feels that genetic screening will enhance enjoyment by finding sports that a person is good at (Pritchard, 1998).

Pitsiladis and Scott (2005) are not in favour of genetic TID and offer that simply identifying favourable genes does not account for how these genes will interact or the effect of the environment.

These authors feel that these interactions will not be fully understood for many years. This is an important view given that services are currently available to identify the ACTN3 gene that is expressed in fast-twitch fibres. MacArthur and North (2005) state that physiological tests currently used for TID “actually represent integrated measurements of the effects of multiple genes and environmental influences on the phenotype, whereas genetic tests examine only single isolated determinants” (p336).

The literature surrounding team sports (Falk et al. 2004, Hoare and Warr 2000, Lidor et al. 2005 and Reilly et al. 2000) emphasised the importance of decision-making and game-sense. Therefore applying genetic screening for physiological traits may eliminate individuals whose abilities lie in assessing situations and making appropriate decisions in a game environment. This is supported by the ALRC (1996) who acknowledge that genetic TID will be more useful in sports such as rowing and athletics that rely more on physiology.

Team success is often the result of the interaction between players, not simply the abilities of the individuals within the team. It does appear dangerous for team sports to head down the path of genetic screening and run the risk of eliminating those whose talents lie in analysis rather than execution.

Patel and Graydanus (2002) offer an interesting summation of the ethical dilemma surrounding genetics and talent identification: “Harnessing the full power of biotechnology could transform top level sport. Whether we would want to live with the results of doing that is, of course, another question entirely” (p 253-4).

Conclusion

TID is an important aspect of identifying potential elite performers, particularly in countries that don’t have the luxury of selecting from a large population base. In Australia this has led to the development of the national *Talent Search* program where physiological and psychological tests are used as a basis for selecting scholarship holders who gain access to significant resources to enhance performance. This approach appears most effective in individual sports such as athletics and rowing (Australian Law Reform Commission 1996, Hoare and Warr 2000, Pritchard, C 1998) rather than team sports (Falk et al. 2004, Hoare and Warr, 2000, Lidor et al. 2005, Pienaar et al. 1998, Reilly et al. 2000, Reilly and Gilbourne 2003).

The identification of genes relating to human performance is certainly in its infancy (Perusse et al. 2003) even though services currently exist for identifying genes such as the ACTN3 protein from DNA (Pitsiladis and Scott, 2005). This then leads to the ethical question of whether genetic screening should be implemented with children.

Proponents of this approach offer that it will enable individuals to be guided towards sports that they are more suited for, thereby increasing enjoyment and compliance (Pritchard, 1998). However the opposing view argues that identifying single genes does not account for the interaction between genes and does not consider the influence of environment (Pitsiladis and Scott 2005, MacArthur and North 2005).

As research into this area continues, issues including privacy of genetic information and reliable forms of gene testing will need further investigation in order to formulate clear policies and guidelines to govern this aspect of sport.

In summation this review has identified two key aspects that require further analysis. Firstly, more work needs to be done examining the influence and interaction of genes across a range of athletic parameters; and secondly, the effect of genetic screening on sport participation and the social development of children should be considered in greater depth.

There is no question that genetic screening will become a part of our sporting landscape, however it is *how* we implement and govern this technology that is the crucial factor.

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