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Perspectives: Performance

Genes and Training for Athletic Performance

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Genes are responsible for about half the variation in physical performance between individuals in the population. Genes also account for half the variation in the response to physical training. Genes are probably even more important than training in explaining differences in performance between athletes. Talent identification and selection of an appropriate partner are therefore logical approaches to creating elite athletes.

KEYWORDS: environment, elite athlete, heredity, nature, nurture, talent identification

A few months ago someone on the Sportscience list initiated a discussion about the possibility that "sport performance and sport expertise is entirely the result of hours spent in focused, effortful training rather than innate, inheritable traits". Adaptation to training is so important, he pointed out, that maybe it swamps any contribution from genes. He also suggested that there was little apparent difference between athletes and non-athletes in basic visual and motor skills, so expert performance might be nothing more than a specific skill or physiological adaptation acquired through specific training. He cited a review (Ericsson et al., 1993) to support these notions. He conceded that height and presumably other features of body build contribute to success in certain sports. He also made the reasonable assertion that training for some sports has to begin at an early age for the individual to have any hope of reaching the top.

In the follow-up discussion, several people identified non-inherited factors that affect performance, such as social support. They also identified motivation to train, but it was not clear whether they thought this trait was inherited or acquired. A claim that the abilities of top athletes are innate *and* acquired was backed up by rhetoric but no evidence; the same writer made the unusual claim that innate abilities are modifiable. Someone injected more objectivity by pointing out that the average person's aerobic power cannot be trained to that of an elite endurance athlete, and that there are obvious differences in the physical abilities of children who have had little or no training.

In all this discussion, there was little reference to published work. In particular, no-one referred to the work of the Bouchards (Claude and Thomas J). In my understanding of it, the work of the Bouchards is definitive: genes account typically for half of the variation in performance between individuals. In other words, when you compare the physical performance of individuals, heredity is as important as all other influences combined. The Bouchards have also shown that heredity determines at least half the variation in the *response* to training, and that therefore inherited differences in performance do not arise simply from an inherited drive to train. To put it another way, if you take a random sample of individuals and train them all the

same way, you will not end up with everyone on the same level of performance. Clearly, athletes are individuals who inherit the ability to respond well to training.

Claude Bouchard and coworkers based their early work on analysis of performance within and between families, including twins in some studies. The group is now looking at the association between specific DNA sequences and performance. So far they have found little or no association, presumably because performance is determined by many genes and/or they haven't struck gold yet. For a good brief review of the recent and earlier work of Claude Bouchard's group, see the introduction to their paper in the October issue of Medicine and Science in Sports and Exercise (Wolfarth et al., 2000). The comprehensive familial study by another group (Maes et al., 1996) is also an outstanding contribution to this field. The statistics are daunting, but the conclusions about the importance of heredity are clear.

Thomas J Bouchard's main claim to fame is studies of twins separated at birth. The closest he and his colleagues got to physical performance is a training study involving a visual skill (Fox et al., 1996). More than half the variation in initial ability was inherited, and the contribution of heredity actually increased with training.

In a follow-up message I sent to the Sportscience list, I made the remark that twin studies are probably the best for resolving the nature-nurture debate. Someone commented astutely that the shared prenatal environment, rather than shared genes, could account for the similarities in twins. In other words, the variance explained by genes is really variance explained by experience in utero. This criticism does not apply to the study of Fox et al., who based their analysis on differences between identical and non-identical twins separated at birth.

In spite of all the evidence for the role of heredity in physical performance and many other aspects of human behavior, there is still a clique of academics who hold out for the primacy of training and other environmental effects. See for example Howe et al. (1998), who did not discuss or even cite Fox et al. (1996) or Maes et al. (1996). Did they deliberately review the literature in a one-sided adversarial manner, did they not understand the genetics, or did they simply fail to do a literature search? The discovery of a specific performance gene should convince even these academics that heredity contributes to human performance. A promising candidate is the gene for angiotensin converting enzyme (the ACE gene), but at this stage it is hard to reconcile the conflicting findings of the relative effects of the two forms of this gene on training and performance (Montgomery et al., 1997; Gayagay et al., 1998; Montgomery et al., 1998; Taylor et al., 1999; Fatini et al., 2000; Rankinen et al., 2000).

The genetics research has focussed either on the general population or on differences between athletes and non-athletes, but what can we say about the relative contributions of genes and training to performance of elite athletes? There is bound to be less genetic diversity amongst these athletes, because the process by which athletes reach the top in a given sport must result in selection for certain genes. But the same selection pressures probably result in less diversity in the training programs of such athletes, so according to this logic the contribution of heredity may still be about the same as in the general population. Heredity may be even more important in athletes, because an athlete's ability to sustain high training loads without overtraining is probably inherited.

What are the practical implications of the fact that athletes are born *and* made? Here are a few:

- Failure to win is not necessarily failure to train right: you can always blame genes, amongst other things.
- Talent identification is not a futile exercise, because differences in physical ability or in the response to training in young people are not due simply to

differences in prior training. Talent spotters should take into account the sporting prowess of the family of a prospective young athlete.
- Genotyping of prospective athletes will become an option when performance or injury genes have been identified, but many will regard the practice as unethical.
- If you want your kids to be great athletes, marry a great athlete.

Ron Trent, the reviewer of this article, made the following comments…

I don't think that there is any doubt that genes make a contribution to performance. You have cited evidence for 50%. I am not sure I believe 50%, but 50% is in the right ballpark. In the next decade, the exact contribution will be known using technology that is coming on track through the Human Genome Project.

The term "unethical" in relation to genotyping of athletes needs some sort of explanation. Unethical refers to the abuse of drugs or other forms of cheating. I wouldn't equate cheating with the use of DNA markers to identify an elite athlete. In my opinion, using DNA markers is no different to saying to a very short person that he/she will not be chosen for the national basketball team because of their height. Everyone gets very uptight when DNA or genes are mentioned in connection with athletes, yet there is no objection to using DNA to identify diseases or criminals. A coach's career will not last long if the coach selects athletes only on the basis of DNA. However, a coaching career might flourish if the coach gets ahead of rivals by adding DNA information to other selection criteria and good training. I cannot see that such behavior is unethical.

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For the recent messages posted to the Sportscience list on this topic, click here. See also the links to other articles on genes at this site

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