European Master of Science in Health and Physical Activity

1st Year Essay – Module 1 – Biomedical Issues in Health and Exercise

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TITLE: GENETIC VARIATION AS EXPLANATION FOR INDIVIDUAL DIFFERENCES IN PHYSICAL PERFORMANCE – CHALLENGES, OPPORTUNITIES AND PITFALLS? (Pitsiladis/Caporossi)

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Starting into the new millennium (2000s) genomics has become a major topic in athleticism. Studies show that genetic factors appear to be an important part in athletic performance. They have an impact on power, aerobic capacity, flexibility, coordination and temperament. Moreover certain alleles seem to occur more frequent in power sports or endurance sports to then boost the particular performance. Genetic variation is known as the difference in between human beings or groups of people, which makes them unique (Mohapatra and Dixit 2018). Genetic variation is actually important in terms of evolution and brings diversity with it (Ahmetov et al. 2016). What makes it so interesting for sports is to determine whether some athletes will be successful one day and others will never be and which is due to their genetic background. The average estimated heritability in different disciplines in sports is around 66% (Ahmetov et al. 2016). Specifically there seem to be a variation of 40-60% in aerobic performance and cardiac function, 50-90% in anaerobic performance, 30-70% in muscular strength and 20-30% of cardiac organ size (Perusse 8, 2011). So genetics do play a key role in the choice of becoming a professional athlete. In the following paragraphs specific genetic markers and their role in athletic performance will be discussed but also the opportunities and challenges that are involved will be emphasized.

There is significant evidence that human phenotypes influence for example muscle strength, skeletal structure, tendon elasticity, heart and lung size, which leads to the general statement that the genetic background has a huge impact on sports performance. For instance, muscle strength depends specifically on the angle of pannation, on the cros-sectional area (CSA), fiber types and

their size, blood flow, etc. These factors are affected by other physiological processes such as dietary volume, muscle protein synthesis or appetite (Puthucheary et al. 2011). In general genetic markers can be divided up into 7 groups: 1) markers that influence skeletal muscle structure and function, 2) markers that have an impact on the inflammatory and repair processes while and after exercising, 3) markers involved in blood pressure regulation, 4) markers involved in modulation of blood pressure control, 5) markers that regulate the energy metabolism and cellular homeostasis, 6) markers that affect gene expression and mRNA stability, and 7) markers altering cellular signaling pathways. According to Ahmetov et al. (2018) around 155 markers are linked to elite athleticism, which consist of 93 endurance boosting phenotypes and 62 power/strength relating markers. They are located in autosomal genes, mitochondrial DNA, X and Y chromosomes. Chromosome 20 is the only one that does not consist of any sport-related markers (Ahmetov et al. 2016).

One of the first markers that have actually been discovered in the early 2000s and is associated with sceletal muscle structure, function and power athletes is called ACTN-3. This variation of ACTN-3 encodes the alpha-actinin-3 protein and is found in type II (fast twitch) very fast muscle fibers, where it is important to generate explosiveness and powerfulness when contracting the muscle. Several studies have shown that especially the ACTN-3 RR is higher represented in sprint athletes than the ACTN-3 XX (Ma et al. 2013). The XX allele was generally seen as quite low represented in type II muscle fibers (Puthucheary et al. 2011). Another marker, which is by far the best known, is called ACE and with its D allele it is supposed to improve sprint ability as well (Durmic 2019). Although in fact researchers emphasize that a combination of several rare phenotypes is needed to be extraordinary in sports. The chances are lower than 1 in 20 Million to have an optimal genotype for sports and they will decrease correspondingly to the number of polymorphisms (Puthucheary et al. 2011).

Furthermore the type of collagen seems to be another important factor for strength of muscle, tendon and bone. While fast twitch fibers contain more collagen type III, slow twitch fibers contain more collagen type I (Puthucheary et al. 2011).

Puthucheary et al. (2011) state that cardiac size and lung function (specifically forced expiratory volume and forced vital capacity) are essential in endurance sports and depend on genetic predisposition as well. Furthermore the receptor PPAR-alpha seems to have a positive impact on endurance sports too. It is defined as a transcription factor, which is responsible for lipid regulation, glucose and energy homeostasis and in control of body weight and vascular inflammation. In addition to, studies show that a variation of the PPAR-alpha corresponding with a certain G allele, which mostly appears in slow twitch fibers, enhance endurance capacity (Ahmetov et al. 2006).

Durmic (2019) found out that the ACE with the allele I has been identified in endurance runners. While on the other hand in sports, where glucose is being used mainly as energy fuel, the C allele of ACE seems to be more prominent (Ahmetov et al. 2006). However the results of Ma et al. (2013) show that only the ACE II stands in a relation with endurance performance.

Although studies prove that these markers exist and have a positive impact on elite athleticism they also depend on the gene environment expression, the sex and age as well (Bouchard 2015). Furthermore the optimal genetic predisposition needs to be accompanied by effective training programmes and an adequate lifestyle (Ahmetov et al. 2018; Beunen et al. 2010). In addition to Bray et al. (7, 2011) emphasize that there are non-genetic predictors such as demographic and physical factors, parental influence and role modelling, that influence physical activity and performance and are difficult to seperate from genetic factors.

With the knowledge of genetic variation and its impact on elite athleticism, a lot of opportunities open up for the future field of sports. On the one hand genomic–based diagnostics could be introduced. This could not only lead patients to their individualized optimal therapy, but also determine the strengths and weaknesses of athletes and their possibilities of becoming a professional in their discipline. On the other hand it certainly classifies as a challenge to tell young athletes or their parents that they will never be successful in their choice of sports due to their genetic background. Moreover there is a big interest in identifying talents to make the right investments and promotions (Bouchard 2015). Furthermore the development of an athlete can be predicted and also possible pathological states that athletes might tend to, can be identified (Ahmetov et al. 2018).

Genetics is generally classified as a very sensitive and complex subject. Bouchard (2015) emphasizes the complexity of this topic and that it is a necessity to not generalize positive or negative outcomes considering specific polymorphisms or alleles. He states that there is still a lack of knowledge and that the research is still far away from where it is supposed to be. Moreover, findings up to this date must not be taken as advice or guidance for certain decisions (Bouchard 2015). Furthermore a lot of studies have turned out to be pitfalls, not only due to technical limitations, false analysis/interpretation or a low quality laboratory information management system, but also simply because of the complexity of the subject or the utilization of the wrong procedures (Djemie 2016). However since this is a topic that concerns human health, it is absolutely essential to be thorough, careful and to use wise procedures. Therefore future research in this field should strictly focus on good methods and follow certain criteria. Furthermore Bouchard (2015) stresses the importance of experimental studies and unbiased technologies to find out more about

epigenomics, transcriptionomics and genomics.

In conclusion, multiplc studies show that genetic variations have an impact on elite athleticism. It seems that for example power, aerobic capacity, flexibility, coordination and temperament are influenced by such genetic variations. The ACTN-3 and ACE allele have been the most observed. Research indicates that mutations in the genotype ACTN-3 imply better power/strength and explosive performances (Puthucheary et al. 2011). It is proven that the ACE with the G allele occurs mainly in slow twitch fibers and the ACE with the C allele has been found in fast twitch fibers. However the evidence of the ACE II is more significant (Ahmetov et al. 2006; Durmic 2019; Ma et al. 2013).

With the utilization of genome-diagnostics it is possible to identify athletes with extraordinary expressions of certain powerful genes, but this also implies that young athletes, who do not have such genetics will not be able to pursue their dreams anymore if only "talents" are being focused on and promoted. Furthermore it will be possible to find out more about the pathologies or weaknesses of athletes (Bouchard 2013; Ahmetov et al. 2018).

Nevertheless genetics is very complex and still far from being thoroughly researched in and scientists warn from making general statements and using findings as guidelines. Genetics may be partly the explanation for human characteristics but other factors such as environment, sex, parental advice, climate etc. also play a key role in the genome's expression and polymorphism. Future research must keep on focusing on this field and focus on strict methods and replicate studies to have more significant results.

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