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Talent selection and genetics in sport

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Abstract

Whether the performance demonstrated by talented sportsmen is hereditary or acquired later has become subject of research for physical education and sport scientists from past to present. However, training science and trainers wonder how far can reach the higher performance limits emerging as a result of talents available in sportsmen. Studies carried out suggested that the concept of higher performance comes true with aggregated environmental and genetic factors. The aim of our study is to discuss the role played by genetics on the differences in performance of sportsmen and selection of sportive talent.

Key Words: Talent, sportive performance, gene, genetics.

INTRODUCTION

Talent is defined as an extraordinary ability of performance specific to effect area that is partially inherent and can complete its development in the early stage (23). But in the field of sport the concept of talent is defined as a higher performance obtained in different branches by individuals thought to have special or top-level predisposition due to hereditary or acquired behavioral conditions. The aim of talent selection in sport is identify sportsmen suitable to the characteristics of the sportive branch selected. In sport, in order to reach a higher performance talented sportsmen should be selected timely and correctly and included in long-term, systematically planned trainings. Age for beginning trainings, first achievements, ages where optimal and higher performances are obtained have been the subject of research for academic investigations carried out on different age groups and branches.

Since the thought of healthy life, rather than the concept of performance, is in the foreground in individuals participating in exercises, the concept of talent does not carry weight. However, the concept of talent is important when sport is performed for "competition". Today, concerning that the investments made to sport and sportsmen have reached serious amounts, selected and elite sportsmen are important in terms of understanding the importance of the subject.

The overloading caused by higher performance limits expected by trainers from amateur and professional sportsmen and the psychological alterations resulted from this overloading have created new sportsman prototype. The first prominent feature in the analysis of this new sportsman prototype is the reality that to reach success children should be trained after talent selection is performed in the direction of their interest and talents (62). Therefore, selecting talented children at early ages and with correct methods is very important for long-term higher sportive performance (28, 55).

Importance of Talent Selection and Genetics in Sport

In sportsmen selection the multi-dimensional activity training should take place in the forefront not performance oriented to branch. In this stage what should be done is to discover children's inabilities in endeavors related to multi-dimensional activity training and sport and to identify their physical development levels and genetic characteristics (60).

One of the most important factors that should be considered during talent selection is genetic characteristics of sportsman. Hereditary factors that present in cell chromosomes, enable emergence of hereditary characters of live individuals by carrying them and are transferred from generations to generations are called genes; the hereditary science that binds the transfer of these characters from one generation to another to certain hereditary laws and investigates the structure and duties of gene is called genetics (26).

The greatest feature of genes is to interact with each other despite they appear working alone and to act together in formation of hereditary characteristics. Furthermore, just like how living creatures are affected by the environment they are in, also genes interact with each other and the surroundings (41). Considering this, it is impossible to say the notion that "a gene is a characteristic" is true. If a person possesses a different genetic structure it also possesses hereditary characteristic produced by that gene. In addition, genes decide how sportsmen will respond to trainings and other environmental factors affecting their performance (30). For example, while a sportsman possessing genes that affect his durability negatively has potential to respond to durability trainings applied, he will be more successful than those having genes that affect this ability positively (49). Besides, genes' direct effect on hereditary characteristics is one of the important topics that genetic determinism concentrates on (43).

Sport and Genetics Relationship

As our genetic structure determines not only our hair and eye color but also all metabolic processes, it is the indication of which sport branch we predispose to (25). When these predispositions are reviewed it is understood that gender, age, anatomical characteristics, physiological equilibrium, nervous system and cardio-vascular structure and basic and auxiliary biomotor abilities are among the determinants of sportive performance. For example, when structure of skeletal muscles are examined it can be seen that they are composed of two separate fibril types; rapidly and slowly contracting fibrils. The fibril type prevalent in our body has been determined genetically. Those fibrils that contract rapidly and produce extreme power exhaust quickly whereas those that contract slowly enable us to sustain a particular effort long time (25). These features play an effective role in selecting the type of sportsman required by durability and speed sport activities and it is known that the numbers of mitochondria that enable energy consumption in cell are related to genetic structure (33).

In obtaining higher performance fulfilling the requirements of exercises, regular nourishment and higher motivation are other important features that should be paid attention. In addition to sportsmen's these features, there are investigations demonstrating that the performance differences occurring when sportsmen's physical capacities are similar result from their personal characteristics (16, 33, 60).

The results obtained from today's performance activities is known to constrain sportsmen's limits and also defended that present limits of performance are performed on the genetic infrastructure. Especially, genes that arrange cardio-vascular and skeletal muscle system are thought to be effective in this subject (5, 34, 42, 58).

The factors affecting the concept of performance that emerges as physiological and psychological interactions can be divided into internal and external factors. We have a very small effect on internal factors that are partially hereditary and differentiate with minor alterations. Many internal factors progress together with adolescence and reach a more stable structure and become more difficult to change (4, 33).

When the effect of genetics on performance was investigated, the first finding was the mutation in erythropoietin receptor gene of Finnish sportswoman Mantyranta who won two gold medals in 1964 Innsbruck Winter Olympics. Investigations demonstrated that the mutation revealed in this gene increased erythrocyte's oxygen carriage capacity 25 -30 % compared to other athletes (24).

Genetic studies are generally carried out with 3 fundamental methods. The first method investigates the hereditary transmission of physical characteristics; the second method makes the genetic map of adult groups with matched physical characteristics; the third method particularly investigates those genes thought to have influence on physical characteristics. Through the second method (one that makes genetic map) the distances among genes can be scrutinized and thereby statistical studies can be conducted on deterministic genes. In addition, genes that affect phenotype by interacting with other genes and the relationship between them can be studied with the help of this method. In the third method, to examine those genes called candidate genes and thought to affect characteristics of the sportswoman mentioned above comprises the important part of the recent studies. Important thing in these studies is to select the candidate gene to be examined and to study this gene together with the data obtained from genetic maps (7).

De Moor et al. (12) reported that twin (dizygotic) sportsmen's performance, who participated in competitions in 20 different sport activities, has been influenced by the hereditary factors at a rate of 66 % and the remaining part was dependent on the environmental factors (12). In addition, in the time course passed from 1960s (13) where the first research was initiated in which the relationship between athletic performance and genetic characteristics was considered up to date, presence of 7 loci and 18 mitochondrial genes over 214 autosomal gene including physical performance and health-related physical fitness phenotypes and X chromosome was reported (6). The relationship based on so strong evidence between athletic performance and genetic characteristics, naturally has led to the idea to use more of these data in the field of sport (20).

In studies conducted a series of standards encompassing genetic structure related to phenotypes of physical performance were developed (29, 64). For example, Williams and Folland (64) investigated 23 different genetic polymorphism in genetic algorithm developed to establish optimal genetic potential related to durability performance (64). Hughes et al. (29) utilized an algorithm based on 22 genetic polymorphisms for optimal muscle strength and power phenotypes (29). In addition, researchers tried to identify some candidate genes in a manner specific to branch in order to reveal genetic profiles of the elite sportsmen in different branches (1, 14).

The examples of genes that can be related to sportive performance are myostatin gene, erythropoetin gene, genes producing growth hormone, nitric oxide synthase (NOS) gene, vacular endothelial growth factor (VEGF) gene, angiotensin converting enzyme (ACE) gene, angiotensinogen (AGT) gene, angiotensin II type 1 receptor (AT1) gene, monocitric (MCT-1) gene, insulin-like growth factor-1-(IGF-1) gene, peroxisome proliferative active receptor (PPAR) genes, C-aktinin-3 (ACTN3) genes (10).

Among these genes, the gene which its relationship with performance has been studied most is ACE gene. It was found that this gene was located at 17^{th} chromosome (67) and there were polymorphisms more than 70 (46). Among these polymorphisms the one most investigated is ACE insertion/deletion (I/D) (67). In studies carried out a set of polymorphisms that decrease or increase enzyme activity in Angiotensin Converting Enzyme (ACE) gene were detected. Some of these polymorphisms were found to increased durability in intensive exercises and caused anabolic effects (46).

In a research conducted it was reported that plasma ACE activity was higher in individuals with ACE D allele than in individuals with ACE I allele (2). In another study carried out with 160 individuals comprised of Turkish sportsmen and sedentary groups ADE I/D polymorphism was investigated and significant difference was found between two groups (61). Besides this, most of the studies examined the relationship between ACE gene and outstanding sportive performance, were performed on non-homogenous groups. To study gene-performance relationship in non-homogenous groups in terms of gender, race, local origin, sportive background and athletic statue may give erroneous results (66). For example, Alvarez et al. (3) examined 60 elite sportsmen and found a positive relationship between ACE II genotype and durability performance. It can be said that 25 of the 60 sportsmen participated in research were cyclists (distance not specified), 20 were long distance runners (distance not specified) and 15 were handball players. However, since sportsmen were in need of different level of $MaxVO_2$, anaerobic threshold, muscular durability and movement economy according to the distance traveled and the requirements of their branches and because trainings were organized according to these requirements it can be said that both this study group was not homogenous and it has fallen short in explaining the relationship between ACE II genotype and durability criteria (10).

In a study Gayagay et al. (18) found a relationship between ACE gene II genotype and durability performance in 64 oarsmen but the length of sportsmen's competition efforts, whether they competed at the same distance or their performance levels were not specified and all sportsmen were studies as one group. Myerson et al. (39) studied a total of 404 sportsmen in 19 sportive branches and concluded that ACE I – allele frequency was not different in experiment group from control group and there was no relationship between ACE I – allele and sportive performance.

The studies mentioned above (3, 18, 40), along with other studies carried out with similar groups, have led the idea that there is a relationship between ACE I – allele and durability performance to become prevalent. However, they could not explain which physiologic parameters of $MaxVO_2$and anaerobic threshold trainings or which aerobic durability class (such as short, medium and long term) would be related to ACE genotypes (or alleles) (10).

In a few homogenous studies it was found that individuals with ACE DD genotype have demonstrated better performance or higher $MaxVO_2$ level (50, 69) in short-term aerobic durability sport requiring $MaxVO_2$ (9). Rankinen et al. (50) in their studies conducted with homogenous subgroups established that among the white parents (n=182) included in a larger heterogenic group (n=724) comprised of 23 black and white families, those with ACE DD genotype have responded to exercises with more $MaxVO_2$ increase. Similarly, more $MaxVO_2$ increase was observed in male undergraduates with ACE DD genotype (69). In a study carried out on homogenous groups with similar training background (n=88), sportsmen with ACE DD genotype had better short-term (6-8 minutes) aerobic durability (9). Again, in a homogenous subject group (n=99) ACE II genotype was found advantageous in force trainings with higher volume and lower intensity and ACE DD genotype in force trainings with lower volume and higher intensity (11). Zhang et al. (68) found relationships between I allele and slowly contracting fibrils (type I) and between D allele and type II fibrils.

In studies conducted with homogenous non-elite subjects groups, those individuals with ACE DD genotype possessed higher $MaxVO_2$ levels (50, 69) and demonstrated better short-term aerobic durability against trainings (9).

When we look at the relationship between ACE gene and anaerobic capacity, anaerobic performance is higher in experiment groups with elevated ACE D allele frequency (39, 40, 66), more increase occurs in lean body messes with exercise (37, 38) and a greater muscular strength develops as a result of resistance trainings (11, 15).

In some studies it was found that ACE D allele was related to elevated $MaxVO_2$ levels (50, 69) and to outstanding performance in medium and long distance swimming sport (59). The muscle strength developed by ACE DD genotypes in response to trainings is more compared to II genotype (11, 15) and they have higher anaerobic capacity (66). Higher rate of type II muscle fibrils possessed by those with DD genotype, support these findings (68). At the same time medium distance runners possess higher rate of type II fibrils (48 – 55 %) (44); therefore, in order for sportsmen with ACE DD genotype to demonstrate outstanding performance in short term aerobic durability the higher MaxVO2 levels may advantageous (10).

In many research a relationship between sportive performance and ACE I/D polymorphism was reported whereas Rankinen et al. (51) concluded that such a relationship was not available elite durability sportsmen. Similarly, Taylor et al. in studies conducted in different sport branches could not find a relationship between ACE genotype and elite sportive performance; however, when sportsmen were separated into subgroups according to gender as performance level of males increased a tendency toward an increase was seen in DD genotype rate (57), similar result could not be found in sportswomen. Sonna et al. (56) reported that ACE genotype did not demonstrate a significant relationship with MaxVO2 or muscular durability performance.

In gene research the most investigated another gene is ACTN3 gene. In studies conducted it was established that the polymorphisms in ACTN3 gene have an effect on sportive performance of individuals (27). Some research suggest that while a sportsmen group is superior in sports such as sprint, football, another group would be superior in sports that require durability (such as marathon). For example, despite absence of R variant after the ACTN3 gene test results of Olympic High Jumpers, they were observed to be the best athletes. Nevertheless, it should be kept in mind that athletes' performance is influenced by a number of environmental factors such as nourishment and accurate training planning (47).

ACTN3 Genotype – Phenotype Relationship

Normal (CC): It was demonstrated in studies that those individuals in which R577X variation was not observed, were advantageous in sports such as body building, judo, short distance swimming, athleticism and bicycling; whereas, they were disadvantageous in other sports requiring durability.

Homozygote Alteration (TT): After research it was determined that those individuals in which a genetic alteration (TT genotype) was observed in both copies of ACTN3 gene, possessed advantageous muscle structure for marathon, triathlon, long distance swimming and bicycling sports that require durability.

Heterozygote Alteration (CT): those individuals in which a genetic alteration (CT genotype) was observed in one copy of ACTN3 gene are prone to all sport types.

Sportsman Health - Genetics Relationship

To examine the relationship between sport and genetics provides information about the health status of sportsmen. For example, while the genes have been associated with athletic performance provide sportsmen with the potential to respond trainings positively, same genes enable more effective function of metabolic process with exercise in sedentary individuals. However, while a series of genes provide capacity to maintain energy long time in durability sportsmen, they may lead to problems related to obesity, diabetes and cardiac diseases in sedentary individuals (49).

In studies conducted it was understood that there were structural alterations in vascular wall according to ACE genotype (21) and a relationship between serum ACE activity and myocardial infarction and coronary artery disease (45). Other studies that investigated the effect of ACE gene on hypertension suggested D/D genotype was an independent risk factor for development of cerebrovascular disease (SVD) in normotensive males and because ACE activity is too much in individuals having D/D genotype, they may be candidates for ventricular hypertrophy at advanced ages due to hypertension, obesity and environmental factors (22). Besides, it was identified in studies that hypertension was a hereditary disorder and especially various gene polymorphisms involving ACE and MTHFR was associated with hypertension (31).

Akar has reported in his disclosure that hemo-concentration after exercise, immobility after sportive injuries, frequent prolonged airline journeys, excessive loss of weight before competition and use of contraceptives may lead to atherosclerosis and atherosclerosis may be more often encountered in those individuals performing heavy exercises and carrying increased hereditary coagulation response. He also suggested that this risk is expected to increase in individuals carrying this type of gene alteration in their "Factor V" gene; when the gene alteration rate of 9 % in healthy Turkish population is considered, examination of this gene alteration may be beneficial especially for those sportsmen with the history of atherosclerosis and sudden young-age death in family (24).

DISCUSSION

It is known that high performance in elite sportsmen occurs with aggregated appropriate environmental conditions such as genetic characteristics, exercise and nourishment (32). In order to understand the alterations in performance of sportsmen both genetic and environmental factors should be dealt with separately and the correlation between genetics and environmental factors should be examined (65).

Table 1. The relationship between ACTN3 genotype and sportive performance (26).

ACTN3 Genotype	Variant	Sport Performance	Some Recommended Sports
Homozygote Normal – CC	RR	• Quick strength • Speed/power • Max. strength • Short term durability	• Body building • Halter • Judo • Athleticism, Swimming, Bicycling (short distance)
Homozygote Alteration – TT	XX	• Medium and long term durability • Continuity in power • Continuity in speed/power	• Marathon • Triathlon • Swimming, Bicycling (longdistance)
Heterozygote Alteration - CT	RX	• Quick strength • Speed/power • Max. power • Long term durability	• Body building • Football, Basketball, Handball, Tennis • Walking, Swimming,Bicycling (short/long distance)

Today, it is thought that identifying sportsmen's biomotor abilities and so the performance potentials to be developed would be possible through genetic scanning. It should be kept in mind that not only one gene but many different genes have influence on development of performance (65). Despite these positive opinions, there are studies questioning how much of the outstanding talents and skills demonstrated at the end of exercises performed to increase performance are dependent on genetic characteristics (52). The results inferred from these studies suggest that to use present genetic tests as a tool in the talent identification process is not possible (8, 20, 36), whereas both physical performance-related phenotypes' and branch-specific candidate genes' allele and genotype distributions should be set forth clearly.

There are many questions and problems brought by talent selection applications based on genetic characteristics. The leading problems are ethical and legal concerns (8, 36, 52, 54). Different from other test methods, the leading ethical problems to be emerged with genetic applications are unable to obtain approval from subjects and unable to maintain privacy of the data obtained (35). In addition, it is thought that genetic studies may lead to ethical problems on issues such as sportsman autonomy and discrimination (53).

In 2008 USA congress voted in favor of an act that prohibits discrimination in genetic data in terms of health insurance and employment. So, USA has supported not to use discrimination based on genetic data (19). WADA stated that 2005 Stockholm declaration did not recommend use of genetic data obtained in sportsman selection for discrimination and this situation does not include present medical screens and investigations (63).

In talent selection to bring genetic characteristics into forefront may cause individuals not predisposed to sport to become discouraged and alienated from sports and those individuals predisposed to sport to receive pressure from their parents about the branch to be selected. Besides, it is worrisome that only wealthy people can access to genetic technology. In this case, deprived sportsmen who are unable to fulfill basic food and health expenses to access genetic technology seems impossible. This situation will expand the gap between wealthy and deprived sportsmen in terms of equal opportunities. Those sportsmen who try to maintain their present performance despite so many impossibilities will not be able to struggle any more against those sportsmen who are genetically predisposed to sport and possessing all kinds of socio-economical possibilities (17).

When all these explanations are considered, it should be kept in mind that when orienting children to different sport branches their physiological and psychological conditions should be taken into account. A child with short parents may be a short child. To orient this child (lacking interest and ability) to such branches as basketball or volleyball where tall body is required and expect outstanding achievement is not right, just like to estrange him from the branch he wanted to select because he is short (25).

Consequently, the discussions related to genetic tests in sportsman selection and the validity of test results remain up to date. Reflecting the data obtained in exercises and making long-term plans is a matter of debate in exercise science. High performance can be achieved through selecting sportsmen having morphological characteristics suitable to branch and long term application of trainings set up on loading-resting relationship and following-up current data related to genetics. When all these data are taken into account, the concept of high performance in sport can be define as the coded directives and organized neuronal cells emerged as a result of combined biomotor abilities developed by sportsmen through self-programs, participation and regularly performed exercises; shortly as increasing the productivity capacity of organisms (48).

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