Review Article

Evaluation of the Effects of Emotional and Violence-Related Genes in Athletes

Abstract

Investigation of the human genome involves the examination of many factors such as gene function, structural features of the genome, chromatin arrangement, recombination rate, and mutation to accurately understand its complex relationship with physiology and diseases. With the sequencing of the human genome, there is an increasing number of studies investigating the influence of genes during the development of behavior and personality traits. Studies show that complex behavior and traits are regulated by multiple genes. In this sense, genes that affect the dopamine pathway are studied in relation to the field of neuroscience. Studies on sports genetics include all of the studies in this field, such as the identification of genes that affect athletic performance, the elucidation of the mechanisms of action of these genes, and the determination of predispositions in terms of athletic performance. Considering the factors that determine success in sports, it is of great importance to create training and nutrition programs suitable for genetic structure not only in individual sports but also in team sports. This study will be presented as a review of the associations in the literature about catechol-O-methyltransferase, 5-hydroxytryptamine transporter, and monoamine oxidase, known in the literature as candidate genes that affect the personality and behavioral characteristics of athletes and are especially related to aggression.

Keywords: *Athletes, genetics, violence*

Buse Sabiha Bozaslan[1], Emel Hülya Yükseloğlu[2]

[1]Autopsy Assistantship, Vocational School of Health Services, Uskudar University, [2]Department of Science, Institute of Forensic Sciences and Legal Medicine, Istanbul University-Cerrahpaşa, Istanbul, Turkey

Introduction

Violent behaviors in athletes can occur in different ways and the basis of these behaviors is frequently observed in competitions. When people who use violence in different societies are examined, it is seen that there are fundamental differences in terms of the causes of violence and the areas where violence takes place, but it is also possible to detect similarities and differences in genetic structures examined by genetic methods.[1] However, this situation should not be considered independent of the social conditions of the individual or society.[2]

Studies on sports genetics include all of the studies in this field, such as the identification of genes that affect athletic performance, the elucidation of the mechanisms of action of these genes, and the determination of predispositions in terms of athletic performance.[3] Considering the factors that determine success in sports, it is of great importance to create training and nutrition programs suitable for genetic structure not only in individual sports but also in team sports.[4]

In studies conducted to investigate aggressive behavior from neurological and genetic aspects, genetic structures and their relations with the environment are held responsible for the variability among people who exhibit aggressive behavior.

It has been seen in the studies that the genetic effect is more pronounced in individuals who deliberately display aggressive behavior than in individuals who display reactive aggressive behavior, and it has been emphasized that the most promising results for genetic studies on aggression are deliberately aggressive individuals.[5]

Aggression has been explained by Baron and Richardson as a form of behavior in which the target individual exhibits avoidance of exposure, with the aim of harming the person it is governed by. Aggressive behavior is defined as the

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: WKHLRPMedknow_reprints@wolterskluwer.com

How to cite this article: Bozaslan BS, Yükseloğlu EH. Evaluation of the effects of emotional and violence-related genes in athletes. J Neurobehav Sci 2022;9:68-71.

Ethics committee approval: There is no need for ethics committee approval.

Received : 27-06-2022
Revised : 26-07-2022
Accepted : 29-07-2022
Published : 31-08-2022

Orcid
Emel Hülya Yükseloğlu {ORCID: https://orcid.org/0000-0003-2009-6065}
Buse Sabiha Bozaslan {ORCID: https://orcid.org/0000-0003-0570-7067}

Address for correspondence:
Buse Sabiha Bozaslan, Vocational School of Health Services, Uskudar University, Uskudar, Istanbul, Turkey.
E-mail: busesabiha.bozaslan@uskudar.edu.tr

Access this article online

Website: www.jnbsjournal.com

DOI: 10.4103/jnbs.jnbs_18_22

Quick Response Code:

behavior with the aim of harming the person to whom it is directed, and damage can be carried out in various ways such as the use of physical force.[6]

It is known that catecholamines (dopamine and norepinephrine), which are frequently mentioned in studies on behavioral genetics and produced in the human body, have vital importance as neurotransmitters in the central and peripheral nervous system. These chemicals are metabolized by monoamine oxidase (MAO). In this respect, it has been determined that this pathway has a significant effect on the determination of personality traits.[7]

In a study conducted with a total of 802 abused and neglected participants, the participants were followed up to adolescence and compared with the participants in the control group to evaluate how anger or aggression-like behaviors develop throughout life. In addition, MAO-A genotypes of these individuals were also examined. As a result of the research, it was found that individuals who were in such environments in childhood and had low gene expression exhibited more behavioral problems throughout their lives. However, statistically, it was also determined that those with high MAO-A expression levels in this group exhibited violent and antisocial behaviors at low intervals during adolescence. Low-level expression of the MAO-A genotype was not found to be a determinant of violence and antisocial behavior in individuals who were not abused in infancy or childhood.[8,9]

Aggressive behavior that is impulsive, particularly in serotonergic systems that are effective in the regulation of the dopaminergic system is known to be related to the deterioration of the balance between most neurotransmitters in the prefrontal cortex. In this respect as a result of studies, receptors 5-HT2 are known to suppress dopaminergic activity and control emotional and behavioral responses, in addition, receptors 5-HT2 reduce serotonergic activity are shown to be associated with impulsive aggressive behavior.[10]

In addition, serotonin, which has various effects on the central and peripheral nervous system, is one of the endogenous molecules. The presence of serotonin, known as a neurotransmitter chemical, in syndromes such as obsession, depression, addiction, and anxiety has been reported in the studies.[11]

Serotonin is thought to be part of an important mechanism that regulates anxiety. Serotonin (5-HT) is a type of hormone that gives the feeling of happiness, vitality, and wellness to individuals. The absence of serotonin causes a depressive, tired, bored mood, and while the chemical of serotonin is released in the brain, the blood vessels contract, and the blood vessels expand when serotonin level drops.[12]

Serotonin transporter protein (SERT or 5-hydroxytryptamine transporter [5-HTT]) is formed by the SLC6A4 gene, which ensures the recall of serotonin from the synaptic gap where it is secreted.[13]

It is known that there is an insertion/deletion polymorphism in the promoter region of the gene, and this allele containing the 44 bp region is called the long allele (L), and the allele without this region is called the short allele (S). Studies in the literature have shown that the S allele may be associated with anxiety and the SS genotype may be associated with aggression in children. In addition, individuals with the LL genotype were found to be more resistant to stress.[14]

The catechol-O-methyltransferase (COMT) gene is located on chromosome 22q11.2 and deletion syndrome may occur on this chromosome. Studies show that structural changes in the prefrontal cortex increase the risk of behavioral disorders and mental illness associated with this syndrome.[15]

In a study, the effect of COMT polymorphism on competitive performance was investigated on 57 male swimmers. According to COMT Val^{158}Met genotype, swimmers were separated as valine homozygous genotype and methionine carrier, and as a result, competitive performance was found to be higher in the methionine carrier group.[16]

In another study conducted with 16 judo athletes and 40 young people as a control group, the COMT gene, which was examined in relation to resistance to stress, personality traits, and aggression, was investigated. In genotypic distributions, it was determined that the Val/Val genotype of the COMT gene was higher in the athletes compared to the control group.[17]

Studies have shown that there is an inverse relationship between blood levels of 5-hydroxyindoleacetic acid, the main metabolite of serotonin, and aggressive behavior and tendency to violence. Genetic variants and polymorphisms mostly associated with serotonin, dopamine, and MAO have been described in individuals exhibiting aggressive behavior.[18] In most of the studies on behavioral traits, it has been shown that genes synthesizing MAO-A, COMT, and 5-HTT enzymes show polymorphism in pathways related to personal behavioral traits, and when the effects of different variants on behavioral tendencies of individuals are examined, violent behavior can be associated with these genes.[19]

Genetic research has included several of the genes related to anxiety, aggression, and depression that may be hereditary with personal differences. However, the 5-HT signal path is defined as (5-HTT), 5-HT1A receptor (HTR1A), and MAO-A.[20]

The 5-HTR1A is located inside the body in the entire gastrointestinal system and in the myenteric plexus. The serotonin receptor is located in the central nervous system in both the presynaptic and postsynaptic regions and the serotonin receptor is the most common.[21] By researchers with mice whose receptors were inactive 5-HT1A with

genetic methods in a study showed reduced aggression and increased fear.[22]

Another study determined that nonviolent suicides had more receptor density of 5-HT1A in their frontal cortex than suicide with violent.[23]

In another study, it was observed that men of a family known to be Dutch nationals demonstrated aggressive and antisocial behavior above normal. In this case, genetic studies on family members determined a mutation that causes the absence of most of the monoaminoxidase enzyme. However, it is known that the enzyme is responsible for the fragmentation of many important neurotransmitters in the brain. In addition, the variants of the MAO (MAOA-L) gene with more extreme activity are shown to cause more serotonin release than gene variants with higher activity (MAOA-H).[24]

Moreover, another study showed that MAO-A activity increased during long-term exercises in individuals and it is explained that it affects fatigue and athletic performance in response to serotonin production. Another study compared groups of individuals dealing with 468 South African triathlon sports with individual control groups who are not interested in this sport and 30 bp Variable Number Tandem Repeat (VNTR) polymorphism was detected on the MAO-A promotor site, and it was found to be directly related to its durability performance in this study.[25]

In another study, it has been observed that there has been an increase in behavioral disorders such as attention deficiency, hyperactivity, and depression, in people with MAOA-L genotypes who have experienced abuse during childhood. On the contrary, people with low MAOA genotype have been overly sensitive to emotional stimulus and increased activity in the amygdala and decreased activity in the frontal regions of their brain were detected.[26]

Conclusion and Recommendations

It is known that dopaminergic functions play a critical role in the behavior of the individual, and most studies show that the dopaminergic neurotransmission system is associated with complex processes such as attention, decision-making, and control.[27]

Individual performance competencies in sports are determined by the genetic structure and are explained as a process in which education and potential are combined. While athletic performance is a result of the interaction between genetics and training, it is known that both talent identification and management systems that provide training are very important in terms of success in sports.[28]

Parameters such as anxiety and aggression, which are known to affect performance in athletes, affect both the daily life of individuals and their success rates in competitions. Since anxiety deeply affects the performance of athletes, it has an important role for individuals to manage their anxiety and perform successfully. It shown that at Table 1; all these emotional states have an impact on the athletes' abilities and athletic performance, as well as their psychological state, due to the hereditary characteristics of genetic diversity. For this reason, it is important to determine the characteristics of stress, competition, and aggression, which have an effect on athletic performance and are known to be related to the processes of serotonergic, dopaminergic, and nonandrogenic systems. In addition, it is stated that the identification of genes that affect psychological states may contribute to the regulation of the athletic performance of athletes.[29]

Table 1: Monoamine oxidase and catechol-O-methyltransferase gene's effect

	Intracellular MAO-A gene	Extracellular COMT gene
Norepinephrine	MHPG, DHPG, VMA	NMN
Serotonın	5-HIAA	
Dopamine	DOPAC, HVA	MT-3

COMT: Catechol-O-methyltransferase, MAO-A: Monoamine oxidase-A, 5-HIAA: 5-hydroxyindoleacetic acid

As a result, it is not possible to associate the complex patterns of behavior that individuals exhibit with a single gene, or these behaviors are only affected by environmental factors. Gained identity and the interaction of the genetic structure and the environment are very important in the essence of behavior in individuals. In addition, epigenetic changes caused by environmental factors and lifestyles differentiate the gene expression but this creates patterns of individual behavior.[30]

In this case, environmental conditions strengthen biological differences, increasing the likelihood of aggressive behavior. Positive environmental conditions can contribute to some polymorphism concealment or the delivery of more positive responses.

Patient informed consent

There is no need for patient informed consent.

Ethics committee approval

There is no need for ethics committee approval.

Financial support and sponsorship

No funding was received.

Conflicts of interest

There are no conflicts of interest to declare.

Author contribution subject and rate

- Emel Hülya Yükseloğlu (50%): Design the research, data collection, and analyze and wrote the whole manuscript. Contributed with comments on research design and slides interpretation.
- Buse Sabiha Bozaslan (50%): Organized the research and supervised the article write up. Contributed with comments on manuscript organization and write up.

References

1. Lippi G, Longo UG, Maffulli N. Genetics and sports. Br Med Bull 2010;93:27-47.
2. Koku FE. Sportif performansın genetik ile ilişkisi. Spor Hekim Derg 2015;50:021-030.
3. McDermott R, Hatemi PK. The relationship between physical aggression, foreign policy and moral choices: Phenotypic and genetic findings. Aggress Behav 2017;43:37-46.
4. Buniello A, MacArthur JA, Cerezo M, Harris LW, Hayhurst J, Malangone C, *et al.* The NHGRI-EBI GWAS Catalog of published genome-wide association studies, targeted arrays and summary statistics 2019. Nucleic Acids Res 2019;47:D1005-12.
5. Waltes R, Chiocchetti AG, Freitag CM. The neurobiological basis of human aggression: A review on genetic and epigenetic mechanisms. Am J Med Genet B Neuropsychiatr Genet 2016;171:650-75.
6. Warburton WA, Anderson CA. Aggression, social psychology of. Int Encyclopedia Social Behav Sci 2015;1:373-80.
7. Lesch KP, Bengel D, Heils A, Sabol SZ, Greenberg BD, Petri S, *et al.* Association of anxiety-related traits with a polymorphism in the serotonin transporter gene regulatory region. Science 1996;274:1527-31.
8. Deckert J, Catalano M, Syagailo YV, Bosi M, Okladnova O, Di Bella D, *et al.* Excess of high activity monoamine oxidase a gene promoter alleles in female patients with panic disorder. Hum Mol Genet 1999;8:621-4.
9. Retz W, Retz-Junginger P, Supprian T, Thome J, Rösler M. Association of serotonin transporter promoter gene polymorphism with violence: Relation with personality disorders, impulsivity, and childhood ADHD psychopathology. Behav Sci Law 2004;22:415-25.
10. Seo D, Patrick CJ, Kennealy PJ. Role of serotonin and dopamine system ınteractions in the neurobiology of ımpulsive aggression and its comorbidity with other clinical disorders. Aggress Violent Behav 2008;13:383-95.
11. Lesch KP. Serotonergic gene expression and depression: Implications for developing novel antidepressants. J Affect Disord 2001;62:57-76.
12. Baumgarten HG, Grozdanovic Z. Role of serotonin in obsessive compulsive disorder. Br J Psychiatry Suppl 1998;(35):13-20.
13. Lesch KP, Balling U, Gross J, Strauss K, Wolozin BL, Murphy DL, *et al.* Organization of the human serotonin transporter gene. J Neural Transm Gen Sect 1994;95:157-62.
14. Caspi A, Sugden K, Moffitt TE, Taylor A, Craig IW, Harrington H, *et al.* Influence of life stress on depression: Moderation by a polymorphism in the 5-HTT gene. Science 2003;301:386-9.
15. Makary MS, Awan U, Kisanuki YY, Slone Hw. Adult-onset leukoencephalopathy with axonal spheroids and pigmented glia: Clinical and imaging characteristics, Neuroradiol J 2019;32:139-42.
16. Abe D, Doi H, Asai T, Kimura M, Wada T, Takahashi Y, *et al.* Association between COMT Val158Met polymorphism and competition results of competitive swimmers. J Sports Sci 2018;36:393-7.
17. Butovskaya M, Veselovskaya E. Molecular-genetic polymorphisms of dopamine, serotonin and androgenic systems as molecular markers of success in judo wrestling sportsmen. J Bioanalysis Biomed 2013;5(S3):e005.
18. Ebstein RP, Segman R, Benjamin J, Osher Y, Nemanov L, Belmaker RH. 5-HT2C (HTR2C) serotonin receptor gene polymorphism associated with the human personality trait of reward dependence: İnteraction with dopamine D4 receptor (D4DR) and dopamine D3 receptor (D3DR) polymorphisms. Am J Med Genet 1997;74:65-72.
19. Edmondson DE, Binda C, Mattevi A. The FAD binding sites of human monoamine oxidases A and B. Neurotoxicology 2004;25:63-72.
20. Waider J, Araragi N, Gutknecht L, Lesch KP. Tryptophan hydroxylase-2 (TPH 2) in disorders of cognitive control and emotion regulation: A perspective. Psychoneuroendocrinology 2011;36:393-405.
21. Pytliak M, Vargová V, Mechírová V, Felšöci M. Serotonin receptors – From molecular biology to clinical applications. Physiol Res 2011;60:15-25.
22. Klemenhagen KC, Gordon JA, David DJ, Hen R, Gross CT. Increased fear response to contextual cues in mice lacking the 5-HT1A receptor. Neuropsychopharmacology 2006;31:101-11.
23. Matsubara S, Arora RC, Meltzer HY. Serotonergic measures in suicide brain: 5-HT1A binding sites in frontal cortex of suicide victims. J Neural Transm Gen Sect 1991;85:181-94.
24. Morishima M, Harada N, Hara S, Sano A, Seno H, Takahashi A, *et al.* Monoamine oxidase a activity and norepinephrine level in hippocampus determine hyperwheel running in SPORTS rats. Neuropsychopharmacology 2006;31:2627-38.
25. de Milander L, Stein DJ, Collins M. The interleukin-6, serotonin transporter, and monoamine oxidase A genes and endurance performance during the South African Ironman Triathlon. Appl Physiol Nutr Metab 2009;34:858-65.
26. McSwiggan S, Elger B, Appelbaum PS. The forensic use of behavioral genetics in criminal proceedings: Case of the MAOA-L genotype. Int J Law Psychiatry 2017;50:17-23.
27. Malloy-Diniz LF, Lage GM, Campos SB, de Paula JJ, de Souza Costa D, Romano-Silva MA, *et al.* Association between the Catechol O-methyltransferase (COMT) Val158met polymorphism and different dimensions of impulsivity. PLoS One 2013;8:e73509.
28. Tucker R, Collins M. What makes champions? A review of the relative contribution of genes and training to sporting success. Br J Sports Med 2012;46:555-61.
29. Corak A, Kapici S, Sercan C, Akkoç O, Ulucan K. A pilot study for determination of anxiety related SLC6A4 promoter "S" and "L" alleles in healthy Turkish athletes. Cell Mol Biol (Noisy-le-grand) 2017;63:29-31.
30. Christians JK. Behavioural genetics. Bioessays 2005;27:664-6.