ROL Spor Bilimleri Dergisi / *Journal of ROL Sports Sciences*
Cilt/Volume: 4, Sayı/No: 4, Yıl/Year: 2023, ss. / pp.: 1423-1436
E-ISSN: 2717-9508
URL: https://roljournal.com/

The relationship between the SLC6A4 gene polymorphism (rs 5-HTTLPR) and aggression in combat athletes

Eda BİLEN[1], Murat ELİÖZ[1]

[1]Ondokuz Mayıs University, Yaşar Doğu Faculty of Sport Sciences, Samsun, Turkiye

Araştırma Makalesi/*Research Article*		**DOI:** 10.5281/zenodo.10377634
Gönderi Tarihi/ *Received:*	Kabul Tarih/*Accepted:*	Online Yayın Tarihi/*Published*:
14.02.2023	20.10.2023	29.12.2023

Abstract

This study aimed to investigate the relationship between the *SLC6A4* gene's 5-HTTLPR polymorphism and aggression levels among elite combat athletes. A total of 40 male athletes from taekwondo (N=10), kickboxing (N=10), boxing (N=10) and wrestling (N=10), aged between 20-35 years, participated in the study. The quantitative data was collected by using a personal information form and the Aggression Scale Inventory. Whole blood samples were taken for DNA isolation and genotyping analysis was performed. In 5-HTTLPR polymorphism, 38.8% (31) had the L allele and 61.3% (49) had the S allele. The highest S allele distribution in 5-HTTLPR polymorphism was found in taekwondo branch (32.7%). In 5-HTTLPR polymorphism, 77.5% (31) and 9% (22.5%) of the athletes had L/S and S/S genotyping, respectively. According to the aggression scale inventory, it was found that the wrestling branch had the highest general aggression mean (114.60), however; there was no significant difference between the sub-dimensions of aggression (Destructive, Attemptive and Passive) in branch comparisons ($p>0.05$). Based on the applied aggression scale inventory and genetic analysis of *SLC6A4* gene 5-HTTLPR polymorphism, it can be considered that the combat athletes participating in the study are tend to aggression.

Keywords: Genetics, combat sports, aggression, SLC6A4, taekwondo

Mücadele sporcularında SLC6A4 gen polimorfizminin (rs 5-HTTLPR) saldırganlık ile ilişkisi

Öz

Bu araştırmada elit mücadele sporcularında SLC6A4 geni 5-HTTLPR polimorfizmi ile saldırganlık düzeyleri arasındaki ilişkiyi incelemek amaçlanmıştır. Çalışmaya yaşları 20-35 arasında değişen taekwondo (n=10), kickboks (n=10), boks (n=10) ve güreş (n=10) branşından toplam 40 erkek sporcu katılmıştır. Nicel verilerin toplanmasında kişisel bilgi formu ve Saldırganlık Ölçeği Envanteri kullanılmıştır. DNA izolasyonu için tam kan örnekleri alınmış ve genotipleme analizleri gerçekleştirilmiştir. 5-HTTLPR polimorfizminde %38,8'inin (31) L aleline ve %61,3'ünün (49) S aleline sahip olduğu belirlenmiştir. 5-HTTLPR polimorfizminde en yüksek S alel dağılımı taekwondo branşında (%32,7) bulunmuştur. Sporcuların 5-HTTLPR polimorfizminde %77.5'inin L/S (31) ve %9'unun (22,5) S/S genotiplemesine sahip oldukları tespit edilmiştir. Saldırganlık ölçeği envanterine göre, güreş branşının en yüksek genel saldırganlık ortalamasına (114,60) sahip olduğu ancak branş karşılaştırmalarında saldırganlık alt boyutları (Yıkıcı, Edilgen ve Atılganlık) arasında anlamlı bir farklılık olmadığı bulunmuştur (p>0,05). Uygulanan saldırganlık ölçeği envanterine ve SLC6A4 geni 5-HTTLPR polimorfizminin genetik analizine dayanarak, çalışmaya katılan mücadele sporcularının saldırganlığa eğilimli oldukları düşünülebilir.

Anahtar Kelimeler: *Genetik, mücadele sporları, saldırganlık, SLC6A4, taekwondo*

Sorumlu Yazar/ Corresponded Author: Eda BİLEN, **E-posta/ e-mail:** edabilenn@gmail.com
Genişletilmiş Türkçe Özet, makalenin sonunda yer almaktadır.

INTRODUCTION

Genetic factors associated with human performance have emerged through the mutual interaction of environmental and individual factors (Ulucan et al., 2015; Bulgay et al., 2023). In addition to environmental factors in the formation and development of athletic performance, a number of factors such as the predisposition of athletes to the sports branch they are doing, their ability to control the emotional and psychological pressure on them both in training and in tough competitions, and their resistance to stress are factors that are highly effective on athletic performance. Therefore, it is extremely important to elucidate gene candidates that affect behavioral traits in athletes (Butovskaya et al., 2013). The slightest disruption in serotonergic, dopaminergic and androgenic systems and the genes belonging to these systems, which are known to be effective on human psychology, causes various mood disorders such as stress, anxiety, aggression, aggression and difficulties in stress control (Ateş et al., 2017).

The serotonergic system is the largest collection of neurotransmitters in the brain, which has been the most researched and informed to date (Tamam & Zeren, 2002; Çelik & Hocaoğlu, 2016). The serotonin transporter gene (*SLC6A4*), which is known to a part of the serotonergic system, is a gene localized on chromosome 17q11.1 q12, containing 14/15 exons, with an average length of 39,500 base pairs (Ramamoorthy et al., 1993; Carlström et al., 2012). *SLC6A4* is the most studied gene in diseases such as major depression and mood disorders (Levinson, 2006). By examining the genotyping of the *SLC6A4* gene, some information about people's personality traits and emotional states can be obtained. Considering the changes in brain serotonergic function, changes in serotonin transporter expression in patients with depression and suicidal attempts, *SLC6A4* gene seems to be highly effective on human health and psychology (Ramamoorthy et al., 1993). Two genetic polymorphisms related to the *SLC6A4* gene, VNTR (Variable Number Tandem Repeats) and 5-HTTLPR, have been identified. *SLC6A4* gene polymorphisms are generally associated with personality traits related to anxiety, depression and aggression (Lesch et al., 1996). In 1996, the most common polymorphism of the *SLC6A4* gene in humans, 5-HTTLPR, was elucidated (Fox et al., 2009). The 5-HTTLPR polymorphism was identified for the *SLC6A4* gene, consisting of 44 base pairs (bp), located in the transcriptional control region of the gene and associated with different numbers of insertion and deletion repetitions consisting of a sequence rich in Guanine (G) and Cytosine (S) (Lesch & Mössner, 1998). 5-HTTLPR (5-HTT gene-linked polymorphic region), which is seen as the most important polymorphism of the *SLC6A4* gene, is located in the promoter region of the gene and is known to have short (S) and long (L) alleles (Lesch et al., 1996; Eken et al., 2018).

It is stated that the "L" allele, the long variant, has higher 5-HTT expression than the "S" allele, the short variant (Lesch et al., 1996). Compared to the L allele, which has a greater role in 5-HTT reuptake, the S allele is less transcribed and causes some psychological disorders (Lesch et al., 1996; Heils et al., 1996). When the genotyping of 5-HTTLPR polymorphism is analyzed, it is found as L/L, L/S and S/S (Heils et al., 1996; Erdal et al., 2000). It is seen that 5-HTTLPR polymorphism plays an important role in the behavior of individuals. It has been predicted that the S/S genotype seen in the polymorphism may lead to more serious problems such as behavioral disorders, aggression, impulse control abilities and problems in learning abilities (Gerra et al., 2005).

In combat sports, being in constant contact with the opponent player causes more body contact than in other sports branches and thus more aggressive behaviors are exhibited (Özerkan, 2004; Weinberg & Gould, 2015). In such sports branches, athletes need to have good psychological characteristics as well as physical characteristics in order to perform better. It is very important for combat athletes to have good mental resilience as well as physical endurance in order to exhibit controlled behaviors under pressure in challenging competition conditions, especially in these sports where one-on-one struggle with the opponent is dominant (Demir & Çelebi, 2019).

The present study aimed to reveal the relationship between *SLC6A4* gene 5-HTTLPR polymorphism allele and genotype distribution and aggression in combat athletes consisting of boxing, kick boxing, wrestling and taekwondo branches. Through the aggression inventory, the psychological tendency of the athletes to aggression will be determined and whether these athletes are genetically predisposed to aggression will be examined by associating with the *SLC6A4* gene.

METHOD

Participants

A total of 40 athletes, including Kick Boxing (N=10), Taekwondo (N=10), Wrestling (N=10) and Boxing (N=10) competitive elite male athletes (Played for national teams, participated in the elite leagues of teams competing in professional leagues or participated in Turkish championships) with a mean age of 25.58 years, who have been actively practicing sports for an average of 11.93 years, were voluntarily and randomly selected to participate in the study. After the informed consent forms were filled, whole blood samples were collected in heparinized tubes (Vacutainer, EDTA Tubes) for DNA isolation. Genotyping was performed in Advanced Technology Research and Application Center (KITAM) Laboratory.

This study is based on a master thesis. The present study was reviewed by University Clinical Research Ethics Committee dated 19.11.2019 and approved by KAEK 2019/686 decision number B.30.2.ODM.0.20.08/768-896.

Genotyping and materials used

DNA isolations were performed from 40 blood samples of Kick Boxing (N=10), Taekwondo (N=10), Wrestling (N=10) and Boxing (N=10) athletes using Cesna blood DNA isolation kit. Concentration and purity values were determined from the isolated DNA samples using Nanodrop 2000 device. DNA samples with appropriate concentration and purity values were subjected to PCR reactions for the amplification of HTTLPR gene regions using Nanodrop 200 device. For the HTTPLR region, 5'- TGC CGC TCT GAA TGC CAG CAC -3' primers were used as forward primaries and 5'- GGG ATT CTT CTG GTG CCA CCT AGA CG-3' primaries were used as reverse primaries. New England M0285L Taq 5x Master Mix was used during the PCR reaction. The reaction conditions were as follows: Master mix 5µl, forward primary 0.5µl, reverse primary 0.5µl, DNA 3µl, ddH2O 16µl, total 25µl for each sample. PCR reactions of the samples were performed at 95˚C for 5 min. denaturation, 95˚C for 45 sec. 45 s at 66.5˚C. 72˚ C for 1 min, 40 cycles at 95˚ C, 45 s at 95˚ C, 45 s at 66.5˚ C, 1 min at 72˚ C and 5 min at 72˚ C for elongation reaction. After PCR, the products were run on a 3% agarose gel at 70 volts for 160 min. Bands of 463 bp (L allele) and 419 bp (S allele) PCR products were observed. For enzyme digestion, a mixture of 10 µl PCR product, 18 µl ddH2O, 2 µl. NEB buffer and 2 µl of MspI enzyme. PCR products were subjected to enzyme digestion reaction with Thermo Scientific Msp I (HpaII) enzyme for 16 hours at 37˚C. The products were then incubated at 80˚C for 20 min for enzyme inactivation. After enzyme digestion, the products were run on a 3% agarose gel and bands were observe

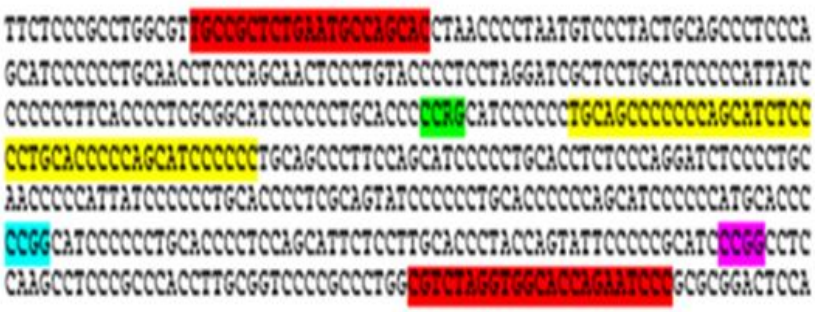

Figure 1. Primary sequence regions used in the study (Homo sapiens solute carrier family 6 member 4 (*SLC6A4*))

The regions marked in red are forward and reverse primary regions of the *SLC6A4* gene. The region marked in yellow shows the insertion/deletion site (44 bp). The region marked in blue is the second MSpI cut site. It provides a positive control. The region marked in pink is the 3rd enzyme cut site.

The scale

In the study, quantitative data were collected by using a 12-item personal information form developed by the researchers to determine the demographic characteristics of the participants and the "Aggression Scale Inventory" developed by İlter Kiper (1984) as a data collection tool (Dervent et al., 2010). The scale consists of 30 items and each item is evaluated on a Likert-type scale ranging from 1-7. The inventory was used to assess the destructive, passive, assertive, and total aggression levels of athletes.

Data analysis

In this study, the data obtained from the participants were analyzed using SPSS 24.00 program. Descriptive analysis methods were used for sociodemographic and clinical data of the sample group. The conformity of the data to normal distribution was evaluated by Shapiro-Wilk test. Variance homogeneity was evaluated with Levene's test. ANOVA was employed to compare the differences between groups (branches), while a chi-square test was utilized to determine changes in allel and genotype based on the different branches.

FINDINGS

To determine whether the genetic aggression levels of combat athletes are effective in the sports they participate in this study aimed to reveal the relationship between the allele and genotype distribution of the *SLC6A4* gene 5-HTTLPR and aggression. In Table 1, the general allele distributions of the 5-HTTLPR polymorphism and the branch-specific allele distributions of the combat athletes were determined. Table 2 shows the general genotype distribution of the

5-HTTLPR polymorphism and the branch-specific genotype distributions of the participants. Table 3 shows the results of the aggression inventory and its subdimensions used to determine the psychological aggression level of the athletes, based on branches.

Table 1. Allele distribution of participants and 5-HTTLPR allele distribution according to sports branches (Allel Distribution, N=80)

5-HTTLPR	L N= 31 (38.8%)	S N=49 (61.3%)	Total	X^2	P
Boxing	9 (29%)	11 (22.4%)	20 (25%)		
Wrestling	8 (25.8%)	12 (24.5%)	20 (25%)		
Taekwondo	4 (12.9%)	16 (32.7%)	20 (25%)	4.371	0.224
Kick Boxing	10 (32.3%)	10 (20.4%)	20 (25%)		
Total	31 (100%)	49 (100%)	80 (100%)		

According to Table 1, the majority of the individuals who participated in the study were found to have the S allele in 5-HTTLPR polymorphism. As a result of the chi-square test, no significant difference was found in the allele distribution between branches ($p>0.05$).

Table 2. Genotype distribution of participants and 5-HTTLPR genotype distribution according to branches (Genotype Distribution, N=40)

5-HTTLPR	L/L	L/S N = 31 (77.5%)	S/S N = 9 (22.5%)	Total	X^2	P
Boxing	_	9 (90%)	1 (10%)	10 (100%)		
Wrestling	_	8 (80%)	2 (20%)	10 (100%)		
Taekwondo	_	4 (40%)	6 (60%)	10 (100%)	11.900	0.008
Kick Boxing	_	10 (100%)	0 (0%)	10 (100%)		
Total	_	31 (77.5%)	9 (22.5%)	40 (100%)		

According to Table 2, more L/S genotypes were found in the 5-HTTLPR region in the athletes who participated in the study. As a result of the chi-square test, significant difference was found in the genotype distribution between branches ($p<0.05$).

Table 3. Comparison of participants' aggression sub-dimensions according to the sports branches

Sub dimensions	Branch	N	Mean± SD	P
Destructive aggression	Boxing	10	27.40±10.99	0.703
	Wrestling	10	32.30±11.98	
	Taekwondo	10	26.40±11.84	
	Kick Boxing	10	29.00±12.62	
	Total	40	28.78±11.63	
Attemptive aggression	Boxing	10	48.70±10.14	0.296
	Wrestling	10	51.10±7.24	
	Taekwondo	10	47.10±10.31	
	Kick Boxing	10	42.70±11.36	
	Total	40	47.40±9.99	
Passive aggression	Boxing	10	22.70±11.19	0.061
	Wrestling	10	31.20±10.43	
	Taekwondo	10	16.90±10.97	
	Kick Boxing	10	22.60±12.77	
	Total	40	23.35±12.09	
Total aggression	Boxing	10	98.80±20.18	0.134
	Wrestling	10	114.60±25.57	
	Taekwondo	10	90.40±26.48	
	Kick Boxing	10	94.30±22.67	
	Total	40	99.53±24.74	

According to Table 3, no significant difference was found in the comparison of aggression sub-dimensions according to branches ($p>0.05$). When the general aggression averages are analyzed, it is seen that wrestling has the highest average, followed by boxing, kick boxing, taekwondo respectively (wrestling>boxing>kick boxing>taekwondo).

DISCUSSION AND CONCLUSION

Are individuals born aggressive or is this an outcome of their social environment? Actually, the fact that the number of studies conducted in this field has proliferated with the development of the field of sports genetics suggests that genetic factors are effective in the basis of all these factors mentioned above. Aggression in the sports environment is mostly determined by the structure and rules of the sports branch of interest and the intentions of the athletes (Erdoğdu et al., 2018). The sports in which aggression is observed more often are combat sports that allow the formation of a one-to-one competition environment. In this study, the polymorphism of the *SLC6A4* gene 5-HTTLPR and its relationship with aggression in elite combat athletes were investigated.

The fact that combat athletes had more S alleles (61.3%) in the 5-HTTLPR polymorphism of the *SLC6A4* gene suggests that they are genetically more prone to aggression (Table 1).

When examining the genetic studies on combat sports; in the study conducted by Ceylan (2020), the fact that 50% of boxers have the S allele seems to support this study. Some studies emphasize that the balance between testosterone - serotonin and testosterone - cortisol is of

great importance in the development of aggression (Josephs et al., 2013; Gronek et al., 2015). Josephs et al. (2013), high cortisol levels were observed in carriers of the S allele with high testosterone, while low cortisol levels were observed in carriers of the L allele with low testosterone. It is suggested that the presence of more testosterone in males than females also triggers aggression (Gronek et al., 2015). Based on the literature, the fact that the sample group in this study consisted of male combat athletes and that males have high testosterone levels could be directly related to the higher rate of the S allele. Looking at the studies outside of combat sports, the athletes in these studies were found to have more L alleles and heterozygotes or homozygotes of the L allele (Ulucan et al. 2014; Filonzi et al. 2015; Petito et al. 2016; Sanhueza et al. 2016; Yiğit 2020; Eken et al. 2021). It is noticeable that the L allele is more prominent in industries other than combat sports. However, the fact that the studies in the literature include athletes of both genders and the sports of interest are not combat sports may have resulted in a lack of parallels with the results of the present study.

In the analysis of the genotyping of the 5-HTTLPR polymorphism of our cohort, although L/S genotyping was found to be more frequent in this study with the exception of the Taekwondo branch, the fact that no L/L genotyping was found at all is one of the remarkable aspects of this study (Table 2). The fact that the athletes in this study had L/S and S/S genotyping may be related to lower 5-HTT activity and intensity. Lower 5-HTT activity and intensity also play an important role in the development of aggression. Gronek et al. (2015) also linked the occurrence of aggression to a specific genetic profile and serotonin deficiency.

Looking at the literature outside of combat sports, we find that the L/L and L/S genotypes dominate in most studies (Saunders et al., 2006; Golby et al., 2006; Sysoeva et al., 2009; Çam et al., 2010; Trushkin et al., 2011; Ulucan et al., 2014; Filonzi et al., 2015; Sanhueza et al., 2016; Petito et al., 2016; Yiğit 2020; Eken, et al., 2021).

In the context of combat sports, Ceylan (2020) found that boxing and wrestling athletes exhibit L/S genotyping. Based on this information, it is hypothesized that the S allele is also present in the genetic structure of athletes to a significant degree and this influences the dominance of L/S genotyping. It can be seen that there are more L/S and S/S genotyping in the combat athletes who participated in this study. Although these athletes turned to combat sports without being aware of their genetic structure, it was found that they actually prefer sports in which they can best manage their existing aggression both psychologically and genetically. This finding suggests that the dominance or recessiveness of alleles and genotypes in genes that

affect athletic performance may also influence the orientation of the combat athletes in the research group toward the sports in which they are interested.

As a result of the aggression inventory conducted with martial artists, no significant finding was found between aggression level and sub dimensions ($p>0.05$) (Table 3). However, when examining the studies that compared the aggression levels of combat athletes and athletes of other sports, combat athletes were found to have higher levels of psychological aggression, and the results of these studies support our study (Tutkun et al., 2010; Tekin et al., 2011; Ceylan 2020; Kostorz & Sas-Nowosielski, 2021).

In this study, it was found that although taekwondo athletes have the lowest aggression scores psychologically, they have the highest aggression genetically. The fact that the concept of virtue conveyed by the sport is fully grasped by Taekwondo athletes, that they have embraced the Far Eastern philosophy of sport because of their affiliation with the culture and traditions to which they belong, that they can develop morally better by adhering to this philosophy, attain mental discipline and anger control, achieve the self-discipline of the sport, and through the trainings they have received, Taekwondo athletes can tame their genetic aggression (Tekin et al., 2011; Weinberg & Gould, 2015; Hernandez & Anderson, 2015; Güvendi & Türksoy-Işım, 2019).

It was found that the boxing and kickboxing athletes who participated in the study had genetically lower aggression scores compared to the taekwondo and wrestling athletes. Boxing, which is known to have originated in England and America, suggests that the differences in sports atmosphere and standard of living in these countries may have an effect on the aggression levels of boxing athletes. At the same time, it can be found that boxers and kickboxers show less aggressive behaviors by reducing their existing aggression through sports (Madden, 1990; Brown, et al., 1995; Hernandez & Anderson, 2015).

It was found that the wrestling athletes in the study had psychologically high aggression scores even though they had genetically low aggression data. Based on the results, it can be said that wrestlers are not genetically aggressive, but learn aggression later due to the environment in which they have been in the middle or low segment (Ersoy et al., 2012). However, the relationship between aggression level and genetic structure is complex and can be shaped under the influence of many factors, and more research needs to be conducted on this topic.

To our knowledge, this is the first genetic study in Turkey investigating the 5-HTTLPR polymorphism of the *SLC6A4* gene in competitive athletes. However, there are some limitations

in this study. These are: (a) the small number of combat athletes in our cohort, (b) the inclusion of a limited number of sports in the field of combat sports, (c) the sample group consists of male athletes only. Future studies are very important to clarify the effects of different genes on mood in athletes and the relationship between athletic performance and genetics.

It can be said that the combat athletes in this study are aggressive both psychologically and genetically. Elite level combat athletes were found to be heterozygous or homozygous for the S allele. These results suggest that combat athletes who are genetically predisposed to aggression have a higher capacity to become elite. The limited number of genetic studies on combat athletes suggests that more studies should be conducted in this field.

GENİŞLETİLMİŞ ÖZET

GİRİŞ

Sporcularda psikolojik parametrelerle ilişkisi olduğu bilinen genlerin incelenmesi, genetik yapılarına en yatkın olan spor branşlarına yönlendirilebilmeleri adına oldukça önemlidir. Sporcularda bu genlerin incelenmesiyle birlikte stres, kaygı, agresyon ve saldırganlık gibi birçok psikolojik faktörler hakkında da bilgi edinilebilir. Bu araştırmada *SLC6A4* geni ve saldırganlık arasındaki ilişkinin aydınlatılması ve mücadele sporcularının mevcut saldırganlıklarını tespit edip uygun spor branşlarına yönlendirilebilmeleri adına oldukça önemlidir.

Bu çalışmada mücadele sporcularında *SLC6A4* geni 5-HTTLPR polimorfizmi ile saldırganlık arasındaki ilişkiyi ortaya koymak amaçlanmaktadır. Araştırmada kullanılacak olan Saldırganlık Ölçeği Envanteri ile sporcuların psikolojik açıdan saldırganlık düzeyleri ve alınan kan örnekleriyle de genetik olarak saldırganlığa yatkın olup olmadıkları tespit edilebilecektir. Edinilen bulgular neticesinde spor genetiği ve literatüre önemli katkılar sağlayacağı düşünülmektedir.

YÖNTEM

Araştırmaya aktif olarak ortalama 11,93 yıldır spor yapan ve 20-35 yaş aralığında gönüllü olarak seçilmiş 10 Taekwondo, 10 Kick Boks, 10 Güreş, 10 Boks müsabık elit erkek olmak üzere toplam 40 sporcu katılım göstermiştir. Bilgilendirilmiş onam formlarının ardından *SLC6A4* geni DNA izolasyonu için tam kan örnekleri heparinli tüplere (Vacutainer, EDTA Tubes) alınmış, genotiplemeleri OMÜ Karadeniz İleri Teknoloji Araştırma ve Uygulama Merkezi (KİTAM) Laboratuvarında yapılmıştır. Katılımcıların psikolojik açıdan saldırganlık düzeylerini tespit edebilmek amacıyla araştırmacılar tarafından geliştirilen demografik bilgi formu ve Kiper tarafından yapılan "Saldırganlık Ölçeği Envanteri" kullanılmıştır. Verilerin istatistiki analizleri için SPSS 24.00 programı kullanılmıştır.

BULGULAR

Araştırmaya katılan mücadele sporcularının *SLC6A4* geni 5-HTTLPR polimorfizmi alel dağılım frekanslarında istatistiksel olarak anlamlı bir sonuç elde edilememişken, genotip dağılım frekanslarında

ise anlamlı bir farklılık tespit edilmiştir. Katılımcıların psikolojik saldırganlık düzeylerini bulgulayabilmek amacıyla uygulanan saldırganlık envanteri sonucunda anlamlı bir fark tespit edilmemiştir. *SLC6A4* geni 5-HTTLPR polimorfizminde bu araştırmaya katılan sporcuların daha çok S alel dağılım frekansına ve L/S ile S/S genotip dağılımlarına sahip oldukları tespit edilmiştir. Uygulanan saldırganlık envanteri ve yapılan genetik analizler neticesinde spor branşları bazında elde edilen değerlerin değişkenlik gösterdiği bulgulanmıştır.

TARTIŞMA VE SONUÇ

Spor genetiği alanında psikolojik parametrelerle ilişkisi olduğu bilinen aday genler ile çalışmalar yapmak, sporcuların hem psikolojik açıdan hem de fiziksel açıdan kendilerine en uygun olan spor branşlarına yönlendirilebilmeleri adına oldukça önemlidir. Psikolojik parametrelerle ilişkisi bulunan dopaminerjik, noradrenerjik ve serotonerjik sistemlere ait genler insan ruh halinin düzenlenmesinden sorumlu genler olarak bilinmektedirler. Duygu durum bozuklukları, depresif bozukluklar ve saldırganlıkla ilişkisi olduğu bilinen *SLC6A4* geni, serotonerjik sisteme ait olduğu bilinen, psikolojik parametrelerle ilişkili olan bir gendir (Levinson, 2006).

Sonuç olarak, mücadele sporcularının genetik yapılarını ve saldırganlık değerlerini öğrenmek için yaptığımız çalışmamızda, elit düzeydeki mücadele sporcularının S alelinin heterozigotuna veya homozigotuna sahip oldukları görülmüştür. Araştırmaya katılan mücadele sporcularının hem genetik hem psikolojik olarak saldırganlığa yatkın oldukları söylenebilir.

REFERENCES

Ateş, Ö., Çorak, A., Kulaksız, H., Sercan, C., Kapıcı, S., Yüksel, İ., … et al. (2017). Sağlıklı türk genç futbolcularda anksiyete ile ilişkili *SLC6A4* geni promoter "s" ve "l" alellerinin saptanması. *The Journal Of Neurobehavioral Sciences, 4*(3), 95-98.

Brown, D. R., Wang, Y., Ward, A., Ebbeling, C. B., Fortlage, L., Puleo, E., … et al. (1995). Chronic psychological effects of exercise and exercise plus cognitive strategies. *Medicine and Science in Sports and Exercise, 27*(5), 765-775.

Bulgay, C., Kasakolu, A., Kazan, H. H., Mijaica, R., Zorba, E., Akman, O., … et al. (2023). Exome-wide association study of competitive performance in elite athletes. *Genes, 14*(3), 660.

Butovskaya, P. R., Butovskaya, M. L., Vasilyev, V. A., Lazebny, O. E., Shibalev, D. V., Veselovskaya, … et al. (2013). Molecular-genetic polymorphisms of dopamine, serotonin and androgenic systems as molecular markers of success in judo wrestling sportsmen. *Journal of Bioanalysis and Biomedicine, 5*(S3), 2-6.

Carlström, E. L., Saetre, P., Rosengren, A., Thygesen, J. H., Djurovic, S., Melle, I., … et al. (2012). Association between a genetic variant in the serotonin transporter gene (*SLC6A4*) and suicidal behavior in patients with schizophrenia. *Behavioral and Brain Functions, 8*(1),1-8.

Ceylan, L., & Eliöz, M. (2022). *Sporcularda SLC6A4 geni ve saldırganlık*. Gazi Kitapevi.

Çam, F. S., Çolakoğlu, M., Tok, S., Tok, İ., Kutlu, N., & Berdeli, A. (2010). Personality traits and DRD4, DAT1,5-HT2A gene polymorphisms in risky and non risky sports participation. *Turkiye Klinikleri, 30*(5), 1459-64.

Çelik, F. H., & Hocaoğlu, Ç. (2016). Major depresif bozukluk tanımı, etyolojisi ve epidemiyolojisi: bir gözden geçirme. *Journal of Contemporary Medicine, 6*(1), 51-66.

Demir, P., & Çelebi, M. (2019). Spor bilimleri fakültesinde eğitim gören mücadele sporcularının zihinsel dayanıklılıklarının incelenmesi. *International Journal of Contemporary Educational Studies, 5*(2), 188-199.

Dervent, F., Arslanoğlu, E., & Şenel, Ö. (2010). Lise öğrencilerinin saldırganlık düzeyleri ve sportif aktivitelere katılımla ilişkisi (İstanbul ili örneği). *Uluslararası İnsan Bilimleri Dergisi, 7*(1), 521-533.

Eken, B. F., Akpınaroğlu, C., Arslan, K. S., Sercan, C., & Ulucan, K. (2018). Genlerin sporda psikolojik faktörlerle ilişkisi. *The Journal Of Neurobehavioral Sciences, 5*(1), 56-61.

Eken, B. F., Polat, T., Aslan, B. T., Ulucan, K., Doğan, C. S., & Oktay Ş. (2021). Futbolcularda *SLC6A4* promotör polimorfizminin dağılımı. *Spor ve Performans Araştırmaları Dergisi, 12*(3), 212-22.

Erdal, E. M., Herken, H., Barlas, Ö., & Erdal, N. (2000). Serotonin transporter gen polimorfizmi. *Klinik Psikiyatri,* (3), 192-196.

Erdoğdu, M., Koçyiğit, M., Kayışoğlu, N. B., & Yılmaz, B. (2018). Futbol ve futsal branşlarında spor yapan genç kadınların saldırganlık yaklaşımları. *International Journal of Cultural and Social Studies, 4*(3), 1-14.

Ersoy, A., Tazegül, Ü., & Sancaklı, H. (2012). Güreşçilerin saldırganlık düzeylerinin sosyo-demografik açıdan incelenmesi (Ankara Örneği). *Uluslararası İnsan Bilimleri Dergisi, 9*(1), 385-397.

Filonzi, L., Franchini, N., Vaghi, M., Chiesa, S., & Marzano, N. F. (2015). The potential role of myostatin and neurotransmission genes in elite sport performances. *Journal of Biosciences,* (40), 531-537.

Fox E., Ridgewell, A., & Ashwin, C. (2009). Looking on the bright side: biased attention and the human serotonin transporter gene. *Proceedings of the Royal Society B: Biological Sciences, 276*(1663), 1747-1751.

Gerra, G., Garofano, L., Castaldini, L., Rovetto, F., Zaimovic, A., Moi, … et al. (2005). Serotonin transporter promoter polymorphism genotype is associated with temperament, personality traits and illegal drugs use among adolescents. *Journal of Neural Transmission,* (112), 1397–1410.

Golby, J., & Sheard, M. (2006). The relationship between genotype and positive psychological development in national-level swimmers. *European Psychologist, 11*(2),143-148.

Gronek, P., Wieliński, D., & Gronek, J. (2015). Genetic and non-genetic determinants of aggression in combat sports. *Open Life Sciences, 10*(1), 7-18.

Güvendi, B., & Türksoy-Işım, A. (2019). Moral disengagement and aggression in fight sport athletes. *Journal of Education and Training Studies,7*(7), 118-123.

Heils, A., Teufel, A., Petri, S., Stöber, G., Riederer, P., Bengel, D., … et al. (1996). Allelic variation of human serotonin transporter gene expression. *Journal of Neurochemistry, 66*(6), 2621-2624.

Hernandez, J., & Anderson, K .B. (2015). Internal combat sports training and the reduction of hostility and aggression in combat sports students. *Psi Chi Journal of Psychological Research, 20*(3),169-176.

Josephs, R, A., Telch, M. J., Hixon, G., Evans, J. J., Lee, H., Knopik, V. S., … et al. (2013). Genetic and hormonal sensitivity to threat: testing a serotonin transporter genotype×testosterone interaction. *Psychoneuroendocrinology, 37*(6),752–761.

Lesch, K. P., & Mössner, R. (1998). Genetically driven variation in serotonin uptake: is there a link to affective spectrum, neurodevelopmental, and neurodegenerative disorders?. *Biological Psychiatry, 44*(3),179-192.

Lesch, K. P., Bengel, D., Heils, A., Sabol, S. Z., Greenberg, B. D., Petri, S., … et al. (1996). Association of anxiety-related traits with a polymorphism in the serotonin transporter gene regulatory region. *Science, 274*(5292), 1527-1531.

Levinson, D. F. (2006). The genetics of depression: a review. *Biol Psychiatry, 60*(2), 84-92.

Madden, M. E. (1990). Attributions of control and vulnerability at the beginning and end of a karate course. *Perceptual and Motor Skills, 70*(3), 787-794.

Özerkan, K. N. (2004). *Spor psikolojisine giriş*. Nobel Yayınları.

Petito, A., Altamura, M., Luso, S., Padalino, F. A., Sessa, F., D'Andrea, G., … et al. (2016). The relationship between personality traits,the 5htt polymorphisms, and the occurrence of anxiety and depressive symptoms in elite athletes. *Plos One, 11*(6), 1-13.

Ramamoorthy, S., Bauman, A. L., Moore, K. R., Han, H., Yang-Feng, T., Chang, A. S., … et al. (1993). Antidepressant and cocaine sensitive human serotonin transporter: molecular cloning, expression, and chromosomal localization. *Proceedings of the National Academy of Sciences, 90*(6), 2542-2546.

Sanhueza, J. A., Zambrano, T., Bahamondes-Avila, C., & Salazar, L.A. (2016). Association of anxiety-related polymorphisms with sports performance in chilean long distance triathletes: a pilot study. *Journal of Sports Science and Medicine, 15*(4),554-561.

Saunders, C. J., Milander, L., Hew-Butler, T., Xenophontos, S. L., Cariolou, M. A., Anastassiades, L. C., … et al. (2006). Dipsogenic genes associated with weight changes during ironman triathlons. *Human Molecular Genetics, 15*(20), 2980-2987.

Sysoeva, O. V., Maluchenko, N. V., Timofeeva, M. A., Portnova, G. V., Kulikova, M. A., Tonevitsky, A. G., … et al. (2009). Agression and 5HTT polymorphism in females: study of synchronized swimming and control groups. *International Journal of Psychophysiology, 72*(2),173-178.

Tamam, L., & Zeren, T. (2002). Depresyonda serotonerjik düzenekler. *Klinik Psikiyatri, 5*(4),11-18.

Tekin, A., Tekin, G., & Eliöz, M. (2011). Kick-Boksörlerin çeşitli değişkenlere göre öfke ve saldırganlık düzeylerinin araştırılması. *Türkiye Kickboks Federasyonu Spor Bilimleri Dergisi, 4*(1),34-48.

Trushkin, E. V., Timofeeva, M. A., Sysoeva, O. V., Davydov, Y. I., Knicker, A., Struder, H., … et al. (2011). Association of *SLC6A4* Gene 5-HTTLPR polymorphism with parameters of simple and complex reaction times and critical flicker frequency threshold in athletes during exhaustive exercise. *Sports Medicine,* (150), 471-474.

Tutkun, E., Güner, B. Ç., Ağaoğlu, S. A., & Soslu, R. (2010). Takım sporları ve bireysel sporlar yapan sporcuların saldırganlık düzeylerinin değerlendirilmesi. *Spor ve Performans Araştırmaları Dergisi, 1*(1), 23-29.

Ulucan, K., Sercan, C., & Bıyıklı, T. (2015). Distribution of angiotensin-1 converting enzyme insertion/deletion and α-actinin-3 codon 577 polymorphisms in turkish male soccer players. *Genetics and epiGenetics,* (7), 1-4.

Ulucan, K., Topal, E. S., Aksulu, B. K., Yaman, B., Çiftci, İ. C., & Bıyıklı, T. (2015). Atletik performans, genetik ve gen dopingi. *İstanbul Kanuni Sultan Süleyman Tıp Dergisi, 7*(2), 58-62.

Ulucan, K., Yalçın, S., Akbaş, B., Uyumaz, F., & Konuk, M. (2014). Analysis of solute carrier family 6 member 4 gene promoter polymorphism in young turkish basketball players. *The Journal Of Neurobehavıoral Sciences* (1), 37-40.

Weinberg, R. S., & Gould, D. (2015). *Spor ve egzersiz psikolojisinin temelleri.* Nobel Akademik Yayıncılık.

Yiğit, S., Polat, T., Doğan, C. S., Tunalı, S., Ekmekci, R., & Ulucan, K. (2020). Determination of *SLC6A4* promoter L/S polymorphism in professional volleyball players and comparison of the literature. *The Journal of Neurobehavioral Sciences, 7*(2), 66.

KATKI ORANI ***CONTRIBUTION RATE***	**AÇIKLAMA** ***EXPLANATION***	**KATKIDA BULUNANLAR** ***CONTRIBUTORS***
Fikir ve Kavramsal Örgü *Idea or Notion*	Araştırma hipotezini veya fikrini oluşturmak *Form the research hypothesis or idea*	Murat ELİÖZ
Tasarım *Design*	Yöntem ve araştırma desenini tasarlamak *To design the method and research design.*	Murat ELİÖZ Eda BİLEN
Literatür Tarama *Literature Review*	Çalışma için gerekli literatürü taramak *Review the literature required for the study*	Eda BİLEN
Veri Toplama ve İşleme *Data Collecting and Processing*	Verileri toplamak, düzenlemek ve raporlaştırmak *Collecting, organizing and reporting data*	Eda BİLEN
Tartışma ve Yorum *Discussion and Commentary*	Elde edilen bulguların değerlendirilmesi *Evaluation of the obtained finding*	Eda BİLEN

Destek ve Teşekkür Beyanı/ *Statement of Support and Acknowledgment*

Bu çalışmanın yazım sürecinde katkı ve/veya destek alınmamıştır.

No contribution and/or support was received during the writing process of this study.

Çatışma Beyanı/ *Statement of Conflict*

Araştırmacıların araştırma ile ilgili diğer kişi ve kurumlarla herhangi bir kişisel ve finansal çıkar çatışması yoktur.

Researchers do not have any personal or financial conflicts of interest with other people and institutions related to the research.

Etik Kurul Beyanı/ *Statement of Ethics Committee*

Bu çalışma, Ondokuz Mayıs Üniversite Klinik Araştırmalar Etik Kurulu tarafından 19.11.2019 tarihinde incelenmiş ve KAEK 2019/686 B.30.2.ODM.0.20.08/768-896 karar numarası ile onaylanmıştır.

The present study was reviewed by Ondokuz Mayıs University Clinical Research Ethics Committee dated 19.11.2019 and approved by KAEK 2019/686 decision number B.30.2.ODM.0.20.08/768-896.