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Allelic Variants on *SLC6A3* Neurotransmitter Gene and Their Relationship with Personality Traits Scales in Egyptian Athletes

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Abstract

Human dopamine transporter gene (*SLC6A3*) is one of the neurotransmission genes that plays an important role in controlling the behavior and psychological reactions toward various physical activities. The aim of the present study is to evaluate the associations between *SLC6A3* 3'-UTR VNTR (3'VNTR) genotypes and eight personality traits in Egyptian athletes. One hundred athletes (50 males and 50 females) and one hundred non-athletes participated in this investigation either in individual or team games. The Freiburg Personality inventory-Revised questionnaire was applied to athletes to evaluate personality traits according to the scale, at a scheduled time, using descriptive analysis. Genotyping for *SLC6A3* 3'-UTR VNTR polymorphism in athletes was realized to detect the different genotypes by PCR amplifications using desired primers. Three different genotypes of the 3'VNTR polymorphism; namely (9/9), (9/10), (10/10) were identified. The 9/10 and 10/10 genotypes of *SLC6A3* gene were significantly higher in players than those in the control group. There were no statistically significant differences in personality traits values among males and females. The Cronbach's alpha stability coefficient for four items is higher than 0.7 suggesting that these items (Neuroticism, Aggressiveness, Depression and Excitability) have a good reliability and support the used personality dimensions for this investigation. Our findings revealed a significant association between the genotypes of 3'VNTR and the personality traits in Egyptian athletes. These data shed light on the role of *SLC6A3* gene in athletes' behavioral performance and could serve as the basis for further characterization in the large number of Egyptian athletes.

Keywords: *SLC6A3* gene, 40 bp-VNTR polymorphism, DAT1, personality traits, athletes, Egyptian population

Introduction

Personality traits are the result of hereditary, human health and disease and environmental influence [1]. The natural genetic variants in the human genome displayed an effective implication in the individual behavior that could contribute to the level of athletic performance and related physical activity. The importance of personality traits evaluation and their interactions with athletes' performance and expecting behavior were emphasized [2-4]. Twin and adoption studies have revealed that the heritability influences on human personality are ranged from 30 to 60%. Besides, many of the

genetic variants have a possible impact on the development, but few have been identified [5]. Technical advances in DNA genotyping and sequencing have enabled the detection of the natural genetic variants that may have an effective association or impact on the level of athletic performance [6].

Numerous candidate genes with putative roles in sport performance have been suggested [7]. The human dopamine transporter gene plays an important role in controlling the behavior and psychological reactions toward various physical activities [8]. Dopamine (DA) neurotransmission represents a main endophenotype for measuring the changes in

executive processes between individuals which constitutes Self-regulation behavior [9]. Furthermore, it is also one of the essential monoamine neurotransmitters in the central nervous system to regulate motivation, emotion, and cognition [10].

The *SLC6A3* gene coding for the dopamine transporter (DAT1) is located in chromosome 5p15.33 and consists of 15 exons and 14 introns. In the 15th exon, there is a variable number of tandem repeat (VNTR) of a 40-base pair (bp) in the 3'-untranslated region (UTR) ranging from 3 to 13 times [11]. In fact, the 9- and 10-repeat polymorphisms are the most frequent which are suggested to be linked with DA-related psychiatric disorders and personality traits [12]. The *SLC6A3* 9-repeat allele is expressed lower than the 10-repeat allele in human cells [13-15], while another work stated the opposite [16]. However, the *SLC6A3* gene expression in extra synaptic striatal fraction revealed that the 10-repeat allele is highly expressed, followed by a decrease in DA levels as confirmed with single-photon-emission computed tomography [13,17]. It is noteworthy that the importance of the *SLC6A3* gene in regulating presynaptic DA homeostasis was characterized in transgenic mice lacking this gene [18]. Interestingly, mice without DAT1 present a spontaneous hyperlocomotion [19].

Allelic variants of the *SLC6A3* gene have been implicated in human health and disease. For example, executive function components associated with *SLC6A3* genotypes are observed in children with Attention-Deficit/Hyperactivity Disorder (ADHD) especially with the homozygous 10/10 genotype [20]. In contrast, Dresler et al. [21] found that the 9/9 & 9/10 repeat genotypes are associated with ADHD in patients with alterations in cognitive response and prefrontal brain function. Lee [2] explored the association between personality traits, environmental and physiological variables, and *SLC6A3* genotypes in a group of 120 New Zealand students. This study showed that genetic effects for *SLC6A3* on neurotic and sensation-seeking traits are masked by gender and ethnicity. In addition, one hypothesis is that DA transporters within the striatum in the brain moderated the dopaminergic system and psychological outcomes in children's self-regulatory capacities [9].

Several researchers have provided strong evidence for an association between the 40 bp-VNTR repeats of *SLC6A3* gene and personality traits. Michałowska-Sawczyn et al. [3] studied this association in Polish players and they proposed that differences in athletes' personality traits are related to the allelic variants of the *SLC6A3* gene. In this regard, the impact of new psychoactive substances (NPS) on personality traits, and its relationship with VNTR 3'-UTR polymorphisms were analyzed [4]. The 9/10 VNTR showed the highest score of neuroticism in NPS users compared to control subjects. No previous studies have been conducted in Egypt to confirm and characterize this association. The aim of this investigation is therefore to assess the relationship between personality traits scales (using the Freiburg Personality inventory- Revised

(FPI-R) Questionnaire) with allele and genotype frequencies of the 40 base pair *SLC6A3* VNTR 3' UTR polymorphism in Egyptian athletes versus control.

Material and Methods

Subjects

One hundred athletes (50 females and 50 males) and one hundred healthy controls (non-athletes) participated in this investigation either in individual or team games. Participants were aged from 18 to 21 years old. The athletes blood samples were chosen according to the following criteria: (a) first-class players and Egyptian team; (b) players to be registered in appropriate sport federation; (c) players should be trained continuously for two years at least; (d) have participated in tournaments organized by sport unions. The Freiburg Personality inventory (FPI-R) Revised (FPI-R) questionnaire was administered to athletes to evaluate personality traits scales on a typical day of training using the descriptive approach due to its relevance to the nature of the study [22]. Furthermore, a control group was defined as 50 men and 50 women to realize comparison with athletes in *SLC6A3* alleles and genotypes frequencies.

Blood sampling and DNA Isolation

Approximately 5 mL of blood was collected from the peripheral blood of each player into EDTA tubes. Genomic DNA was isolated from blood using the QIAamp DNA extraction kit (Qiagen, Germany) according to the manufacturer's protocol. DNA was eluted in deionized water and then stored at -20°C until genotyping analyses. The quality of DNA was determined in a Nanodrop spectrophotometer (ThermoScientific, USA) at 260 nm and 280 nm absorbance ratios. A ratio of 1.8-2.0 indicates purity of DNA samples. Moreover, DNA samples were electrophoresed on a 1.5% agarose gel to confirm the integrity and quality of the extracted DNA. A ladder 1 kb DNA marker (ThermoScientific, USA) was used as a molecular weight reference.

Genotyping for 40 bp-VNTR polymorphism of *SLC6A3* gene

The 40 base pair *SLC6A3* 3'-UTR VNTR genotypes were detected by PCR amplification using targeted primers: F- 5'TGTGGTGTAGGGAACGGCCTGAG-3' (forward) and R- 5'CTTCCTGGAGGTCACGGCTCAAGG-3' (reverse) [9]. The mixture of PCR reaction was applied in a total volume of 25 µl containing 100 ng DNA, 20 pmol of each primer, 200 mmol/L dNTPs, 1x reaction buffer, 1.5 mmol/L MgCl₂ and 1U of Taq DNA polymerase (Promega, USA). The amplification was realized on the following conditions: an initial denaturation of 5 min at 95°C, followed by 50 cycles of denaturation (95°C, 30s), annealing (63°C, 30 s), and elongation (68°C, 45s), and a final elongation step at 72°C for 5 min. The PCR products were separated by electrophoresis on a 2.5 % agarose gel.

The Freiburg Personality inventory- Revised (FPI-R) scales analysis

FPI-R scales were applied to detect personality profiles of studied athletes [23] and were translated and validated for the Egyptian population in Arabic by Allawi et al. [22]. These personality parameters consist of eight traits namely; neuroticism, aggressiveness, depression, excitability, social orientation, security, self-direction, and emotionality. The FPI is composed of 56 questions classified by eight personality traits and each scale, consisting of seven statements. Moreover, participants were asked to choose an answer for each statement according to their opinions, on a two-point Likert scale ranging from totally agree to nothing agree. The positive answer takes (2) points with totally agree and (1) point with disagree whereas the negative answer takes (1) point with totally agree and (2) points with disagree respectively.

Statistical analyses

The data were analyzed using the SPSS software (Ver. 18.0 IBM). The normality of data distribution was tested with the Shapiro-Wilk test. To assess differences in personality variables between studied players and control subjects, t-tests were

performed. A Spearman correlation coefficient and Cronbach's alpha stability coefficient were used to measure reliability, or internal consistency. *SLC6A3* genotype and allele frequency comparison between groups were performed using a chi-square test. Significance level was considered with a p-value of less than 0.05. Hardy-Weinberg equilibrium (HWE) was performed in order to determine genotypes frequency and their distribution in the studied subjects.

Results

SLC6A3 3'-UTR VNTR genotypes

Two main alleles of *SLC6A3* 3'-UTR VNTR genotypes were presented in athletes under study. These alleles were: the 9-repeat allele with a length of 440 bp and the 10-repeat allele with a molecular length of 480 bp are shown in **Figure 1**. The distribution of the *SLC6A3* 3'-UTR VNTR genotype and allele frequencies were presented in **Table 1**. Three different genotypes were detected as follows: the homozygous 9/9 genotype (athletes 10.0% vs. controls 47.0%); the homozygous 10/10 (athletes 58.0% vs. controls 33.0%) and the heterozygous 9/10, (athletes 32.0% vs. controls 20.0%). The homozygous 10/10 genotype and heterozygous 9/10 of *SLC6A3* gene

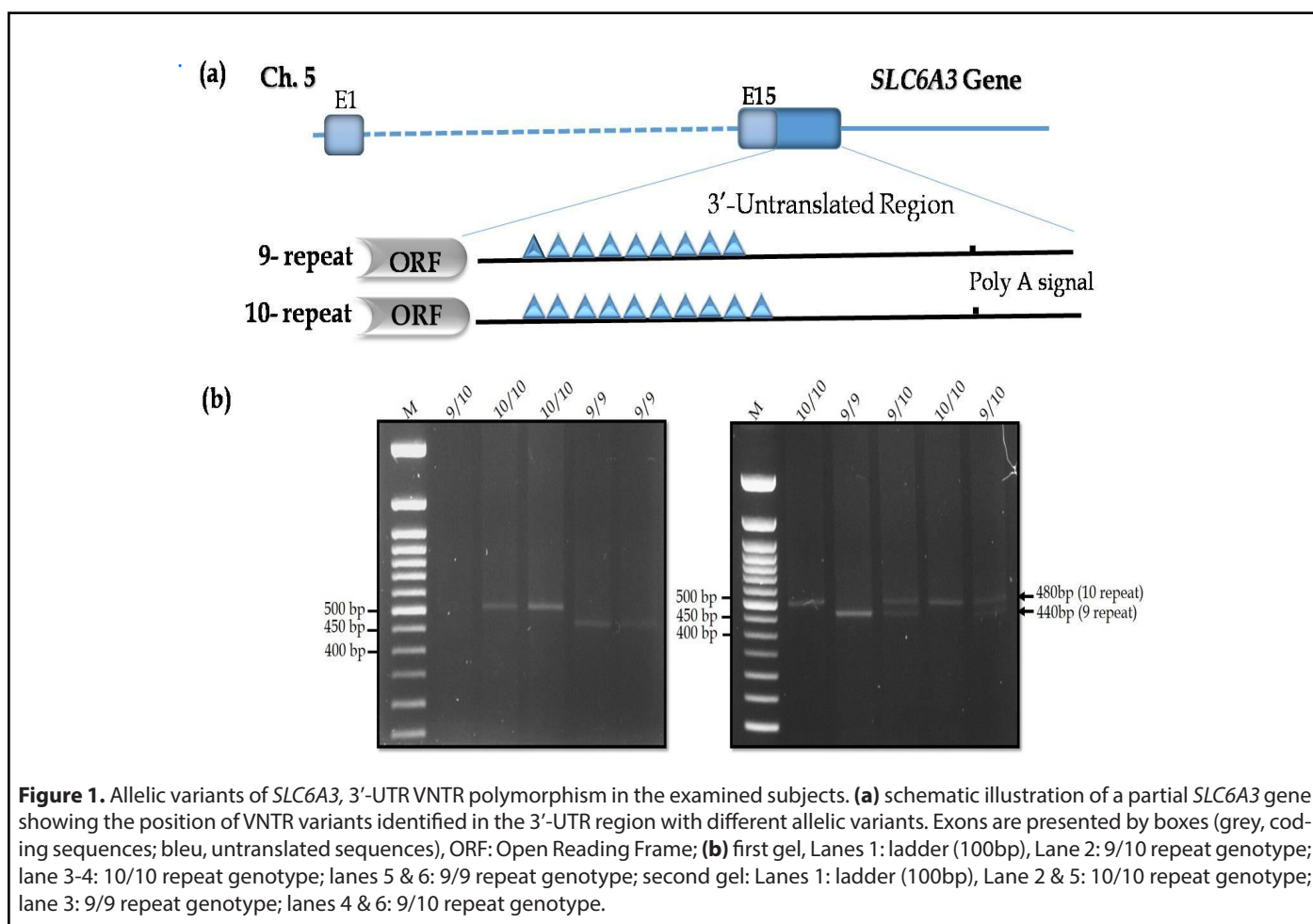


Table 1. Genotypic distribution and relative allele frequency for SLC6A3 3'-UTR VNTR gene polymorphism in athletes and controls.						
SLC6A3 3'-UTR VNTR						
Groups	Genotypes				Alleles	
	Total N	9/9 N (%)	9/10 N (%)	10/10 N (%)	9 N(%)	10 N(%)
Athletes	100	10(10%)	32(32%)	58(58%)	52(26%)	148(74%)
Control	100	47(47%)	20(20%)	33(33%)	114 (57%)	86 (43%)
χ^2	33.65				19.79	
<i>p</i> value	0.0001				0.0001	
χ^2 (HWE) Athletes	2.83					
<i>p</i> value	0.518					
χ^2 (HWE) Control	32.3					
<i>p</i> value	0.0000754					
N: Number of participants, p: Statistical significance						

frequencies were significantly higher in players than that in the control subjects (Table 1, *p* value =0.0001). Interestingly, genotype 9/9 was much higher in the control group than in the athletes group. The 9-allele frequency was approximately two-fold higher in the control group than in the athletes group (26.0%), whereas the frequency of the 10-allele may be higher in the athletes group (males and females, 74.0%) than in the control group (43.0%). All identified polymorphisms were in the Hardy-Weinberg equilibrium in the players' samples but not in the control subjects as shown in Table 1.

Personality traits scale

A trait is a dynamic, relatively stable general tendency to a certain type of behavior and its effect appears in a large number of life situations [24]. The FPI-R scales score was performed for athletes under evaluation and compared to their genotypes. Genetic association between SLC6A3 3'-UTR VNTR genotypes and FPI-R scales score is presented in Table 2. The 9/9 genotype for SLC6A3 gene was more prevalent with scores between 12 and 14 in Depression, Social orientation (80.00%) and Emotionality (80.00% each), followed by neuroticism (60.00%). The 10/10 genotype was more prevalent in Aggressiveness (59.60%), followed by Excitability and Self-direction (both 28.10%). Moreover, the heterozygote 9/10 genotype was more prevalent in Security (57.60%).

There is no statistically significant relationship between the gene genotypes and the scales of personality traits, although

it is close to the significant value in aggressiveness as shown in Table 3. The research sample is homogeneous on the Freiburg list of personality scales and that it has a similar level of these traits within each genotype (Table 4). The differences between males and females on the Freiburg personality list for the main research sample are not statistically significant (Table 5). Thus, the basic research sample will be treated as one group that includes males and females in the statistical analysis. The Cronbach's alpha stability coefficient for 4 items is higher than 0.7 suggesting that these items (Neuroticism, Aggressiveness, Depression and Excitability) have a good reliability and support the used personality dimensions for this investigation (Table 6).

Discussion

Human athletic performance traits such as neuroticism, depression, social orientation, aggressiveness, excitability, self-direction, security, and emotionality are the result of the interaction between genetic and environmental influences, with polygenic basis in exercise-related traits [25]. This investigation highlights the role of 40 bp-VNTR polymorphisms of SLC6A3 gene in athlete's personality traits and its influence on athletic performance. There are different factors affecting athletic performance that are well established: intensity and type of training, anthropometric characteristics as well as an important psychological component. However, the contribution of the genetic background has been less investigated [26]. Moreover, variation in personality parameters

Table 2. Genotypes frequency of SLC6A 3'-UTR VNTR gene and percentage for the studies player's scores on the Freiburg personality inventory (FPI-R) scales.

Scale no	FPI-R scales	Player Score														
		SLC6A 3'-UTR VNTR Frequency and Percentages														
		Score	8		9		10		11		12		13		14	
Genotypes	n	%	n	%	n	%	n	%	n	%	n	%	n	%		
1	Neuroticism	9/9 (n=10)					2	20	2	20	4	40			2	20
		9/10 (n=33)					7	21.2	8	24.2	6	18.2			12	36.4
		10/10 (n=57)					18	31.6	16	28.1	16	28.1			7	12.3
2	Aggressiveness	9/9 (n=10)			2	20			4	40			4	40		
		9/10 (n=33)			12	36.4			6	18.2			15	45.5		
		10/10 (n=57)			7	12.3			16	28.1			34	59.6		
3	Depression	9/9 (n=10)							2	20	4	40			4	40
		9/10 (n=33)							8	24.2	6	18.2			19	57.6
		10/10 (n=57)							16	28.1	16	28.1			25	43.9
4	Excitability	9/9 (n=10)	4	40			4	40			2	20				
		9/10 (n=33)	6	18.2			19	57.6			8	24.2				
		10/10 (n=57)	16	28.1			25	43.9			16	28.1				
5	Social orientation	9/9 (n=10)							2	20	6	60			2	20
		9/10 (n=33)							8	24.2	18	54.5			7	21.1
		10/10 (n=57)							16	28.1	23	40.4			18	31.6
6	Security	9/9 (n=10)					6	60			4	40				
		9/10 (n=33)					14	42.14			19	57.6				
		10/10 (n=57)					32	56.1			25	43.9				
7	Self-direction	9/9 (n=10)			2	20	6	60			2	20				
		9/10 (n=33)			7	21.2	18	54.5			8	24.2				
		10/10 (n=57)			18	31.6	23	40.4			16	28.1				
8	Emotionality	9/9 (n=10)	2	20							4	40			4	40
		9/10 (n=33)	8	24.2							19	57.6			6	18.2
		10/10(n=57)	16	28.1							25	43.9			16	28.1

Table 3. Correlation between SLC6A 3'-UTR VNTR genotypes with the Freiburg personality inventory scales.

FPI-R scales	Spearman Correlation coefficient
Neuroticism	-0.195
Aggressiveness	0.196
depression	-0.074
Excitability	0.023
Social orientation	0.037
Security	-0.070
Self-direction	-0.037
Emotionality	-0.023

*Significant at P<0.05 (tabular Spearman correlation coefficient = 0.197)

Table 4. Homogeneity of the main research sample on Freiburg personality inventory scales within SLC6A3'-UTR VNTR genotypes.

Genotypes	FPI-R scales	Means ± SD	Shapiro-Wilk Test	
			Value	indication
9/9 (n=10)	Neuroticism	11.8 ± 1.398	0.892	0.178
	Aggressiveness	11.4 ± 1.578	0.856	0.053
	Depression	12.6 ± 1.265	0.860	0.054
	Excitability	9.6 ± 1.578	0.870	0.059
	Social orientation	12.2 ± 1.033	0.887	0.176
	Security	10.8 ± 1.033	0.871	0.059
	Self-direction	10.8 ± 1.033	0.886	0.176
	Emotionality	12.00 ± 2.309	0.874	0.062
9/10 (n=33)	Neuroticism	12.06 ± 1.619	0.879	0.068
	Aggressiveness	11.18 ± 1.828	0.876	0.066
	depression	12.91 ± 1.331	0.896	0.186
	Excitability	10.12 ± 1.317	0.875	0.067
	Social orientation	12.18 ± 1.044	0.851	0.055
	Security	11.15 ± 1.004	0.890	0.184
	Self-direction	10.82 ± 1.044	0.851	0.055
	Emotionality	11.39 ± 2.091	0.857	0.057
10/10 (n=57)	Neuroticism	11.33 ± 1.272	0.880	0.187
	Aggressiveness	11.95 ± 1.42	0.888	0.195
	depression	12.6 ± 1.307	0.871	0.185
	Excitability	10.0 ± 1.512	0.882	0.187
	Social orientation	12.35 ± 1.203	0.880	0.187
	Security	10.88 ± 1.001	0.890	0.195
	Self-direction	10.65 ± 1.203	0.891	0.195
	Emotionality	11.44 ± 2.322	0.885	0.191

Table 5. Differences between males and females on the Freiburg personality inventory scales (FPI-R) for the main research sample (n1 = n2 = 50).

FPI-R scales	Male	Female	T- value
	Means ± SD	Means ± SD	
Neuroticism	11.62 ± 1.41	11.62± 1.47	0
Aggressiveness	11.64 ± 1.59	11.64± 1.64	0
Depression	12.66 ± 1.3	12.74± 1.32	-0.305
Excitability	9.96 ± 1.48	10.04± 1.43	-0.275
Social orientation	12.26 ± 1.12	12.3± 1.15	-0.176
Security	10.92 ± 1.01	11± 1.01	-0.397
Self-direction	10.74 ± 1.12	10.7± 1.15	0.176
Emotionality	11.52 ± 2.27	11.44± 2.21	0.178

*Significant at P <0.05 (Tabular T = 1.984)

Table 6. Stability of the Freiburg personality inventory scales by Cronbach's alpha method (n = 50).

FPI-R sub-scales	Phrase (N)	Cronbach's alpha stability coefficient		Stability coefficient in case of item removed		FPI-R sub-scales	Phrase (N)	Cronbach's alpha stability coefficient	Stability coefficient in case of item removed	
		Sub-scale	Total scale	Sub-scale	Total scale				Sub-scale	Sub-scale
Neuroticism	3	0.784	0.778	0.676	0.488	Social orientation	12	0.742	0.706	0.598
	4			0.676	0.488		28		0.700	0.601
	15			0.669	0.500		48		0.700	0.601
	18			0.776	0.488		2		0.738	0.590
	23			0.723	0.691		14		0.736	0.488
	38			0.723	0.699		47		0.650	0.522
	54			0.723	0.699		51		0.708	0.588
	7			0.710	0.738		1		0.636	0.587
Aggressiveness	10	0.779	0.778	0.778	0.706	Security	20	0.738	0.682	0.598
	26			0.702	0.753		29		0.708	0.488
	27			0.702	0.570		42		0.708	0.488
	41			0.702	0.570		43		0.640	0.600
	44			0.697	0.731		45		0.675	0.689
	49			0.703	0.728		56		0.654	0.679
	21			0.650	0.488		9		0.648	0.621

Depression	25	0.761	0.778	0.650	0.488	Self-direction	11	0.725	0.701	0.618
	34			0.650	0.488		16		0.713	0.732
	37			0.760	0.602		22		0.715	0.567
	40			0.760	0.602		24		0.705	0.770
	52			0.760	0.575		30		0.665	0.699
	55			0.759	0.583		50		0.676	0.699
	5			0.710	0.748		6		0.700	0.592
Excitability	31	0.800	0.778	0.710	0.740	Emotionality	8	0.782	0.732	0.488
	33			0.704	0.753		13		0.732	0.488
	36			0.704	0.745		17		0.767	0.567
	39			0.727	0.705		19		0.767	0.567
	46			0.750	0.581		32		0.771	0.567
	53			0.738	0.589		35		0.771	0.567
	3			0.676	0.488		12		0.706	0.598

is one important component of human individuality and this variation is due to the interaction of interindividual differences in genes and environment [27].

The frequent alleles namely; the 9-repeat allele and the 10-repeat allele have effective effect on *DAT1* expression due to DA reuptake from extracellular space [14,15,28-30]. Allelic variants could modify the gene expression profiling due to changes in regulatory sequences which affect the binding of transcription factors and related elements. Consequently, the gene product pattern will be modified [31]. In the present study, we identified that the 10-repeat allele was common in the athletes group and to be related to personality traits examined in the participants under study, whereas the 9-repeat allele was less common for the same group. It seems to be important for athletic performance. Bielinski et al. [32] showed an association between depression and angry-impulsive traits and the 9-repeat allele of *SLC6A3* gene, which is in accordance with our results.

HWE tells geneticists where to look to find the causes of evolution in the population. Surprisingly, the population of Egyptian athletes is at the HWE suggesting an ideal population with assumptions of random mating, absence of selection or mutation and equal viability and fertility hold [33]. However, interestingly, the control population is not at HWE, suggesting a genetic drift or migration, which could alter genotype and allelic frequencies.

These findings showed that the effect of polymorphisms in the 40 bp-VNTR repeats of *SLC6A3* gene may synergize and result in impaired dopaminergic signaling. The variation in athletes personality traits scale could be due to the difference

in genotypes distribution of *SLC6A3* gene and result in impaired DAT activity and DA signaling. Our results are in accordance with Miller & Madras [30] who provide experimental evidence that 40 bp-VNTR repeats of *SLC6A3* gene may influence levels of DAT protein in the brain and affect human personality traits. Besides, dopamine plays an important role in several brain functions and is involved in the pathogenesis of several psychiatric and neurological disorders [34].

Athlete's behavior tends to be stable to some extent and this is what is called "stability of behavior", therefore the trait is a fixed style of behavior that distinguishes one individual from another [35]. Besides that, a new trend of personality investigation has shed the light on the significance of natural differences intraindividual which constitutes the essential base for various behavior and feeling across the changeable situation and time [36].

Genetic association between *SLC6A3* 3'-UTR VNTR genotypes and FPI-R scales score revealed that the 9/9 genotype was more common in neuroticism, depression and social orientation, whereas the 10/10 genotype was more common in aggressiveness, excitability and self-direction. Moreover, the heterozygote 9/10 genotype was more common in security and emotionality.

However, it can be concluded that studying athletic personality is important to identify dominant traits and how to deal with it, as this helps in: 1) giving the true indicators that it should be used in selecting juniors and players, which makes the sports training process more effective as it is focused on athletes who have the qualifications to succeed. 2) developing physical, skill and planning preparation programs



aimed at gaining them motor abilities of the practiced sports activity. 3) determining the appropriate methods to follow in preparing athletes considering individual differences between the players. 4) studying the psychological aspect of an athlete's personality helps those in charge of his preparation in determining the size and intensity of the competitions that must be completed in the sports season.

The relationship between sport performance including creativity and neurotransmitter genes or brain-related genes such as the SLC6A3 3'-UTR VNTR polymorphism is not well characterized. The recent findings by Kitazawa et al. [37] present the influence of neurotransmitters in the CNS (central nerve system) and physical performance. Moreover, these results revealed that Dopamine could be responsible for the neurotransmission regulation in the CNS which will subsequently increase the athletic performance phenotypes. Such interested findings could prove to be valuable implications for future treatment strategies.

Recent investigations have emphasized the importance of personality traits evaluation and their relationship with athletes performances and expected behavior [2-4]. In this study, four personality traits seem to be important. Firstly, the aggressiveness trait is more prevalent in 10/10 genotype, followed by 9/10 genotype. This indicates that high score on this subscale refers to athletes who automatically submit physical, verbal, or imaginary aggression acts and respond emotionally and confront others with attacks and quarrels. They also characterized by impulsivity, inability to control themselves, lack of calmness and emotional immaturity. Moreover, three other traits are interesting: 1- the neuroticism trait is more prevalent in 9/9 genotype, followed by 9/10 genotype. This indicates that high score on this subscale distinguishes athletes who suffer from physical disorders (such as blood circulation, breathing, and digestion disorders, etc.), movement disorders (such as feeling pain), general psychosomatic disorders, sleep disturbances, fatigue, tension, rapid feeling of fatigue, sensitivity to weather changes, loss of comfort, and clarity of some nervous and physical manifestations associated with emotional arousal. 2- Depression trait is more prevalent in the 9/9 genotype, followed by 9/10 genotype. This indicates that a high score on this subscale distinguishes athletes who characterized by depression, mood swings, pessimism, feeling unhappy, dissatisfaction, fear, feeling unspecified fears, loneliness, lack of others understanding them, inability to focus, tendency to aggression against self, and feeling guilty. Low score on this subscale distinguish athletes who are of moderate temperament, the ability to focus, reassurance, self-confidence and contentment. 3- Excitability trait is more prevalent in 10/10 genotype, followed by 9/10 genotype. This indicates that the high score in this subscale distinguishes athletes who characterized by high arousal, high tension, inability to face normal daily frustrations, annoyance, impatience, anger, aggressive responses when frustrated, irritability, and of sensitivity.

Other studies showed a significant association between SLC6A340 bp-VNTR polymorphisms and suicidal behavior [38], ADHD disorder [39], and Eating Disorders with Binge Eating Behavior [40]. However, these data could provide a framework and new insights into the identification of additional candidate genes involved in the modulation of personality traits and sports performance, as well as the potential related disorders.

Conclusions

The current findings revealed a significant association between the genotypes of SLC6A3, 3'-UTR VNTR and personality traits in Egyptian athletes even with insufficient scales limitations. The 10 R-allele was more common in the athletes group than the 9 R-allele. This association will highlight the importance of SLC6A3 polymorphism as a brain-related gene in the variation of personality profile and its impact on the physical performances among athletes. Besides, this data could help in the classification of athletes and their behavior in order to find the effective genotype to improve athletic performances and personality parameters. Moreover, these data shed light on the role of SLC6A3 gene in athletes' behavioral performance and could serve as the basis for further genetic screening and characterization in the large number of Egyptian athletes.

Ethics Statement

All subjects under the present study gave their written informed consent before obtaining any samples and performing any personality traits questionnaire. This study was reviewed and approved by the Department of Educational, Psychological and Social sciences, Faculty of Physical Education for Girls, Alexandria University.

Data Availability Statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding authors.

Authors Contributions

AE, contributed to full genetic analysis, and manuscript preparation; MB, collected athlete's samples, performed psychological Questionnaire of the athlete's personality, data analysis, and manuscript preparation. GP, supervising, and manuscript preparation; VL, is the corresponding author, supervising, and manuscript preparation. All authors read and approved the final version of this paper.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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