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The Association between Testosterone and Serotonin Levels and Aggression in Athletes

Sporcularda Testesteron ve Serotonin Düzeyleri ve Saldırganlık İlişkisi

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ÖZET

Amaç: Bu çalışmada sporcular ve sedanterlerde testosteron ve serotonin değerleri ile saldırganlık düzeyi arasındaki ilişkinin araştırılması amaçlanmıştır.
Materyal-Metot: Çalışmaya 18-25 yaşları arasında 60 sporcu (30 basketbolcu, 30 voleybolcu) ve 20 sedanter birey katıldı. Serotonin ve testosteron düzeylerinin belirlenmesi için gönüllülerin önkol cubital venlerinden 5 ml venöz kan örneği jelli biyokimya tüplerine istirahat halinde oturur pozisyonunda alındı. Alınan kan örnekleri 3500 devirde santifirüj edilerek plazma ve serumuna ayrıştırıldı. Elde edilen serumlarda hormon düzeyleri belirlendi. Saldırganlık düzeylerinin belirlenmesi için ise Buss ve Perry tarafından geliştirilen saldırganlık ölçeği kullanıldı. Elde edilen verilerin analizinde tek yönlü varyans analizi, LSD düzeltme ve ilişki kontrolünde Pearsonkorelasyon testleri yapıldı.
Bulgular: Basketbolcu ve sedanterlerde testosteron ve serotonin ile saldırganlık seviyeleri arasında anlamlı bir ilişki görülmedi ($p>0,05$). Voleybolcularda saldırganlık ile testosteron arasında negatif, serotonin ve saldırganlık arasında pozitif yönde bir ilişki tespit edildi ($p<0,05$). Branş bağımsız değişkeni açısından serotonin ve testosteron miktarlarında bir farklılık görülmezken ($p>0,05$), saldırganlık alt boyutlarında voleybolcular lehine anlamlı değişim gözlendi ($p<0,05$).
Sonuç: Sonuç olarak sporcular ve sedanterler arasında testosteron, serotonin miktarları açısından bir farklılık olmadığı, voleybolcuların basketbolcu ve sedanterlere göre daha yüksek saldırganlık puanlarına sahip olduğu söylenebilir.

Anahtar kelimeler: Egzersiz, testosteron, serotonin, saldırganlık

ABSTRACT

Aim: The aim of this study was to investigate the relationship between testosterone and serotonin levels and aggression in athletes and sedentary subjects.
Materials and Methods: 60 athletes (30 basketball plus 30 volleyball players) and 20 sedentary persons between the ages of 18 to 25 participated in the study. Testosterone and serotonin levels in serum of the venous blood samples taken from the subjects were measured in routine biochemistry lab. Aggression Questionnaire developed by Buss and Perry was used to estimate aggression score in the current study.
Results: No significant difference was found any relationship between testosterone and serotonin levels and aggression score of basketball players and the sedentary ($p> 0,05$) In volleyball players, we observed a negative association for aggression and testosterone, while there was a remarkable positive association between aggression score and serotonin level ($p< 0,05$). No significant difference was found in the levels of serotonin and testosterone in the basketball and volleyball players ($p> 0,05$), as significant difference was observed in aggression score of volleyball players compared to testosterone and serotonin levels ($p<0,05$).
Conclusion: As a result of our findings, there are no significant differences between athletes and sedentary in the view of testosterone and serotonin levels, whereas volleyball players have higher aggression scores when compared to basketball players and sedentary.

Keywords: Exercise, testosterone, serotonin, aggression

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INTRODUCTION

In endocrine system, the transport of substances through the cell membrane, growth and secretion functions of cells and their chemical reaction speeds are controlled through hormones secreted by special endocrine glands. These effects of hormones start sometimes within seconds and sometimes within a few days and they continue for weeks, months and even years (Consolazio et al., 1963; Harbili, 1999).

Studies conducted have shown that short term intense exercise and longer submaximal exercise increase testosterone level (Çakmakcı, 2013) In addition to causing increase in testosterone level with exercise, this situation also makes muscle hypertrophy easier (Weiss et al., 1983). Testosterone hormone which has androgenic and anabolic effect has different functions in different stages of life (Özdemir, 2008). Testosterone plays a significant role in differentiation between urogenital organs and external genital organs following week 8 in embryonic period (Bökesoy, 2000; Dökmeci, 2000; Özdemir, 2008), in attaining secondary gender characters in puberty, and in many physiological events such as increase in muscle mass, sexual functions, erythropoiesis, and organization of plasma lipids and bone metabolism in adult males (Bardin, 1996; Kutsal, 1998; Kayaalp, 2005; Özdemir, 2008).

Serotonin is a neurotransmitter which incorporates into a great number of functions in central nervous system and which has a significant role in various behaviours. It has very important functions in sleep mechanism, pain transmission, regulation of temperature and brain blood flow, sexual behaviour, aggressive behaviour and blood–brain barrier permeability (Twarog and Page, 1953; Amin et al., 1954). In addition, serotonin metabolism disorders may be the cause of many pathological situations such as Alzheimer, depression and migraine (Heninger et al. 1984; Eriksson and Humble, 1990; Hartig and Lever, 1990).

"Aggression", which has become a popular research issue on nowadays, is defined in general as all kinds of behaviours which aim to harm any living or non-living being physically and/or emotionally (Özdevecioglu and Yalcin, 2010). Aggression is a behaviour which has existed since the existence of human beings. From the fights in children's games to street fights, and to wars, a person's efforts to cause pain to another being are perhaps one of the most studied behaviours.

It is noteworthy that a couple of field studies have indicated testosterone values raise during the aggressive phases of sports games. Also, testosterone provokes the subcortical areas of the brain to produce aggression, whereas serotonin and cortisol behave antagonistically with testosterone to decrease its effects. Therefore, the aim of our study was to investigate the relation of the testosterone serotonin levels and aggression of athletes and non-athletic (sedentary) subjects.

MATERIAL AND METHODS

Ethics committee approval was received for this study from Clinical Researches Ethical Board of Ondokuz Mayıs University. After that, a total of 80 males, 60 athletes between the ages of 18 to 25 and sport history average 6.8 years, playing in the basketball and volleyball teams of Faculty of Sports Sciences, Ondokuz Mayıs University in Samsun and 20 sedentary who were not doing sports, participated in the present study. Blood samples were taken from the athletes during the training period. While beginning the study, the athletes and the sedentary were explained the practices to be performed within the context of the study and their permissions were taken by making them sign consent forms.

Collecting blood samples

When subjects were hungry at 9.00 a.m. in the morning, 5 ml venous blood sample was taken from the participants. The collected blood samples were centrifuged at 3500 g and then serum separated into plastic tube in order to analye testosterone and serotonin.

Analysis of serum total testosterone

Total testosterone concentrations in serum samples were measured at Department of Biochemistry Hormone Laboratory by using Hitachi Modular Automatic Analyzer E170 device with Cobas Testosterone II commercial kits.

Analysis of serum serotonin

Serotonin levels in serum samples were estimated at the same laboratory by using Human ST ELISA commercial kit (SunRed Biological Technology Co.Ltd., Cat No. 201-12-1129, Shangai, China) through Double-Sandwich ELISA method.

Aggression measurement methods

Aggression Questionnaire developed by Buss and Perry (Buss and Perry, 1992) was used to estimate the aggression scores of the individuals in the study. After that, the scale was adapted into Turkish by Can in 2002 (Can, 2002). The scale consists of five sub components as physical aggression, verbal aggression, anger, hostility and indirect aggression. The participants answered the 34-item questionnaire which was developed to find out 5 different dimensions of aggression with 5 Likert type answers such as (1) extremely uncharacteristic of me, (2) slightly characteristics of me, (3) somewhat characteristics of me, (4) very characteristics of me, and extremely characteristics of me. The lowest score can get from the questionnaire is 34 if subject given one point, while the highest score is 170 (Buss and Warren, 2000).

Statistical analysis

SPSS-22.0 (SPSS-22.0 for Windows-SPSS Inc., Chicago, Illinois, USA) program was used in the statistical analysis of the data obtained as a result of the study. The data were presented as arithmetic mean, standard deviation, minimum and maximum values. Shapiro-Wilk test was performed for normality assumption test. Skew and Kurtosis values were checked for data which were not normally distributed and data sets within ±2 value was considered to have normal distribution. Pearson correlation was conducted to check the association between variables. One-way ANOVA and LSD correction test were conducted for comparisons of multiple groups, while t test was used for two independent groups. Statistical results were assessed at the significance level of $p<0.05$

RESULTS

When the descriptive data of athletes and sedentary were analyzed, basketball players' average age was 21,97±2,16 years and their BMI average was 21,86±1,87 kg/m2, while volleyball players' average age was 21,67±2,15 years and their BMI average was 22,26±0,95 kg/m2. Average age of the sedentary was 22,65±2,11 years, while their BMI average was 22,37±1,29 kg/m2. Descriptive data of athletes and sedentary are shown in Table 1.

As a positive significant association was found in volleyball players between indirect aggression and serotonin ($p<0,05$) (Table 2), there is no differences was found in basketball players and sedentary between testosterone and serotonin and aggression. While no significant difference was found in the amounts of serotonin and testosterone in terms of the athletes and sedentary (Table 3) ($p>0,05$), a significant change was observed in aggression sub dimensions in favour of volleyball ($p<0,05$) (Table 4).

Tablo 1: Descriptive data of athletes and sedentary

	Basketball (mean±SD) N=30	Sedentary (mean±SD) N=30	Volleyball (mean±SD) N=30
Age (years)	21.97±2.16	22.65±2.11	21.67±2.15
Height (cm)	185.1±5.46	176.4±5.55	182.2±5.18
Weight (kg)	74.83±6.22	69.8±7.07	73.97±5.31
BMI (kg/m²)	21.86±1.87	22.37±1.29	22.26±0.95
Sport History (years)	6.87±2.08	None	5.9±1.77

Table 2: Associations between testosterone, serotonin and aggression scores in volleyball players

	Testosterone		Serotonin	
	r	p	r	p
İndirectAggression	**-0,489**	**0,006***	**0,382**	**0,037***

*p<0.05

Table 3: Testosterone and serotonin levels in athletes and sedentary

	Branches	N	Ave.	S.D.	f	p
Testosteron (ng/ml)	**Basketball**	30	4,23	1,98	0,942	0,394
	Sedentary	20	4,30	1,20		
	Volleybal	30	3,77	1,21		
Serotonin (ng/ml)	**Basketball**	30	34,21	29,32	1,261	0,289
	Sedentary	20	37,99	34,99		
	Volleybal	30	47,21	33,54		

Table 4: Aggression score analysis in terms of the variable of athletes and sedentary

Variable	Group	N	Ave.	S.D.	F	p	Significant difference
Total aggression	**Basketball**	30	100,67	6,86	**7,139**	**0,001**	**Vol. - Bas.**
	Sedentary	20	101,10	8,33			**Vol. - Sed.**
	Volleyball	30	107,27	7,20			
Physical aggression	**Basketball**	30	23,40	3,22	**4,590**	**0,013**	**Vol. - Bas.**
	Sedentary	20	24,40	1,82			
	Volleyball	30	25,67	3,13			
Verbal aggression	**Basketball**	30	15,20	2,59	**5,516**	**0,006**	**Vol. - Bas.**
	Sedentary	20	14,45	2,44			**Vol. – Sed.**
	Volleyball	30	16,77	2,60			

DISCUSSION

Aggression is a complex social behaviour with a great number of definitions. The definition by Moyer that "it is an obvious and intentional behaviour to hurt the opposite side or to do something disagreeable" is the most suitable clinical definition (Moyer, 1968). Aggression can present within a wide range of behaviour. Individual behaviours in the form of instinctual whimsical desultoriness are relatively stable during life. Instinctuality is defined as behaviours that cannot be stopped or changes even if their results reach a disturbing dimension (Logan et al., 1997). These characteristics interact with biological and environmental causes.

The brain's structural anomalies which are influenced by genetical, nutritional-environmental factors can form neuropsychological function disorders. Neurotransmitters, hormones, cytokines, enzymes, growth factor and message molecules are in the neurosystem that can cause pathological aggression. Functional or structural disorders that can occur in one or many of these factors can cause instinctual aggression or can cause an increase in the sensitivity to tendency for aggression (Scarpa and Raine, 1997;

Davidson et al., 2000; Oquendo and Mann, 2000). Among these factors which cause the effects of aggression, hormones and especially serotonin and testosterone have been wondered clinically before (Dolan et al., 2001; Birger et al., 2003) and it has been discussed in our study.

When the correlation between aggression scores and amount of testosterone and serotonin levels was examined in our study, no significant association was found between athletes and sedentary ($p>0,05$) (Table 3), while a negative significant correlation was found between indirect aggression and testosterone in volleyball players ($p<0,05$) (Table 2). According to this result, it can be said that as the amount of testosterone increases in volleyball players, indirect aggression decreases. In contrast to th results, in a study conducted with 692 adult male prisoners it was found that prisoners committing personel sex and violent crime had higher testosterone levels than other prisoner (Dabbs et al., 1995).

Recent molecular genetic studies have demonstrated that genes encoding some key proteins involved in serotonin transmission could present some polymorphism in relation with impulsive-aggressive behaviours. In addition, when the association between aggression scores and amount of serotonin was examined, no significant association was found between basketball players and the sedentary ($p>0,05$), while a positive significant correlation was found between indirect aggression and serotonin in volleyball players (Table 2) ($p<0,05$). According to this result, it can be said that as the amount of serotonin increases in volleyball players, indirect aggression decreases.

When basketball players, volleyball players and the sedentary are addressed as one group each, no significant difference was found between groups in terms of the amounts of testosterone and serotonin (Table 4) ($p>0,05$). Kafali et al. (2017)examined the aggression levels of a group of 253 basketball, handball and athletes and they found that individual athletes have more aggressive attitudes than team athletes.

It is known that testosterone organizes masculine organization in the brain by stopping or preventing neural cell death before and after birth. As a result of this, it is thought that in adulthood steroids trigger these ways and cause aggressive behaviour to reoccur through neural ways. On the other hand, it is known that hormones do not directly influence on their own and instead cause some chemical changes which influence the probability of specific behavioural results as a result of the modulation of neural pathways (Siegel et al., 1999). As a result of these, the amount of testosterone has even been associated with dominant character (Dabbs and Hargrove, 1997).

Testosterone is a prohormone which acts like an androgen receptor when transformed into 5-alpha-dihidrotestosterone or like an oestrogen receptor when transformed into estradiole by enzyme aromatase. There is evidence that testosterone can mediate tendency for aggressive behaviour (Schlinger and Callard, 1990). In addition, Schlinger and Callard (1989) showed the intensity of aggressive behaviour to be directly associated with the aromatase activity in the front hypothalamus (Schlinger and Callard, 1989).

Studies conducted on masculine hormones and aggression or crime has shown that men are more aggressive than women. Testosterone can be one of the indicators of aggression level even in infancy. In a study conducted on 28 boys and 20 girls in preschool period, the children were videotaped while playing. Their aggression levels were analyzed based on their games or social states and their testosterone levels were measured. Results showed a positive correlation between testosterone level and aggression level in social states in boys (not girls); however, this result was not found in aggression related with game (Sánchez et al., 2000).

A study conducted on 4.462 men reported that men with higher levels of testosterone were more aggressive, they lived discipline problems, had higher levels of drug use and even lower levels of education and income (Dabbs and Morris, 1990). In another study conducted on 692 adult male convicts, testosterone levels were examined and it was found that those convicted with penalties of violence and sexual abuse had higher testosterone levels and they were found to be more undisciplined against prison rules (Dabbs et al., 1995). In our study all of the 80 volunteers were men. Lack of women may be seen as a deficiency in this study where the relationship between aggression and hormones was investigated.

Another study took the perspective on the issue one step ahead and compared young men and women convicts with university students. Again, similarly, testosterone levels of both men and women convicts were found to be significantly higher than their peers who were not convicts (Banks and Dabbs, 1996).

High level of testosterone is known to be associated with a tendency for violence, antisocial behaviours and criminal behaviours. However, it is obvious that other factors such as low socioeconomic level are also influential on this result. In a study conducted on judicial psychiatric individuals, free testosterone, total testosterone and SHBG (sex hormone-binding globulin) levels were examined. It was found that Type II alcoholism patients had much higher total testosterone and SHGB levels and in addition, in individuals with antisocial personality disorder and social deviation testosterone and SHGB levels were found to be high (Stålenheim et al., 1998).

The fact that all of the subjects in our study were male causes the aforementioned physiological background. In addition, the fact that there were no differences in both testosterone and aggression dimensions in terms of the state of doing sports explains the low or non-existing correlation between these variables in aggression sub-dimensions (Table 4). The result that the levels were close to each other in all groups and that there were no statistical differences is thought to be the reason why there is no correlation between serotonin and aggression levels when the subjects in our study are analyzed under one group.

Serotonin is known to be important in terms of a person's feeling well, being happy and content, having less appetite and having normal levels of sexual impulses (Guizhen et al., 1998). Serotoninhas been reported to be associated with the regulation of emotional state in human beings and the function disorders in brain serotonin have been reported to be associated with situations such as anxiety, panic, agoraphobia, obsessive compulsive disorders and depression (Tanaka and Mukaino, 1999).

Krishnaveni and Shahin expressed that, aggressive and violent actions basketball, football, cricket, etc. context combat sports and like judo, karate and wrestling, or team contact sports like rugby, American football and ice hockey all these high level of aggression and often violent sports (Krishnaveni and Shahin, 2014). The athletes who participated in our research consisted of team athletes with less complete contact, such as basketball and volleyball, led to the fact that groups with less aggression were seen.

Brain stem is the neurotransmitter system the 5-hydroxy-tryptophan (5-HT) raphe of which is distributed most extensively. With this system, serotonergic raphe neurons are diffused to many areas of the brain. In addition, as neurotransmitter role, 5-HT is a significant regulatory in morphogenetic activities in early brain development (Azmitia and Whitaker, 2000). In humans, 5-HT signalization has a duty as the main modulator in emotional behaviours such as anxiety, instinctuality and aggression. Many studies on testosterone activity show a relation between high plasma levels and a tendency towards aggression. The interaction between low serotonin and high testosterone levels in the central nervous system has a significant effect on the neural mechanisms involved in the expression of aggressive behavior. It seems that testosterone modulates serotonergic receptor activity in a way that directly affects aggression, fear and anxiety (Westenberg et al., 1996; Birger et al., 2003). In our study, it has been observed that serotonin activity increases with low testosterone levels, and we can say that testosterone has the opposite effect on indirect aggression and serotonin has the same effect (Table 2).

All of the volunteers who participated in our study were male and homogeneous in terms of mean age. In contrast to our study Mashhoodi and colleagues compared the aggression levels of young and adult athletes in four different sports such as volleyball, football, judo and wushu and they found that young athletes were more aggressive than adult athletes (Mashhoodi et al., 2013).

Gacar conducted a study with the Turkish ski national team in 2012. In this study 9 female and 11 male athlete's aggression levels were examined. According to this study assertiveness level was observed as high while disruptive and passive dimensions of aggression were found low (Gacar, 2015). In our study, unlike Gacar's research, aggression levels were compared by

comparing different sports and sedentaries (Table 1). In addition, the fact that only male athletes took part in our study did not show a similarity according to Gacar's research (Table 4).

5-HT related behaviours have a wide variation as minor (impulsitivity, enmity, psychopathic deviation or violence, personality disorder, antisocial disorder, narcissism and histrionic personality disorder) and major (suicidal tendency, explicit aggressive behaviours, explosive disorders, pathological gambling and alcoholism) (Staner and Mendlewicz, 1997). Aggression and suicidal tendency are frequently seen due to low 5-HT level in the brain (Åsberg, 1997). As can be seen from the explanations, lack of 5-HT can induce aggressive behaviour and this can be shown as a proof for lack of serotonin indirectly (Faustman et al., 1993; XHigley et al., 1996).

CONCLUSION

Although there is information about the effects of serotonin and testosterone on human behaviour as explained above, they are not enough alone to create biological effects, various personalities, behaviours and psychopathology differences. Complex behaviours occur with complex interactions in which environmental, biological and experiential factors are included. In these interactions, testosterone and serotonin as biological factors can only be considered as biological markers which play the major role (Birger and et al., 2003).

There was no correlation between testosterone and serotonin aggression total score and sub-dimensions in basketball players ($p>0,05$) ($p>0.05$). A positive and significant relationship was found between total aggression score and physical aggression, anger and hostility ($p<0,05$) ($p<0.05$). Within the context of the results obtained from our study entitled "The association between testosterone and serotonin levels and aggression in athletes", it was found that testosterone and serotonin levels do not differ between athletes and sedentary and only in verbal aggression sub-dimension athletes were found to have significantly higher scores when compared with sedentary. There was no correlation between testosterone and serotonin aggression total score and sub-dimensions in sedentaries ($p>0,05$) A positive correlation was found between total aggression score and verbal aggression and anger sub-dimensions between verbal aggression sub-dimension and hostility sub-dimension ($p<0,05$).

According to the age variable of athletes, the amount of testosterone and serotonin levels under 20 years, aged 21-24, and over 25 years of age were not statistically significant. There was no statistically significant difference between age groups of athletes in terms of total aggression score and sub-scores of aggressions. There was no statistically significant difference was found between the groups in terms of testosterone and serotonin levels in basketball and volleyball players in terms of branch variables ($p<0,05$).

LSD test results showed that there was a significant difference in total aggression score and verbal aggression sub-dimension in favor of volleyball players between basketball players and sedentaries. In the physical aggression sub-dimension, a significant difference was found between volleyball players and basketball players in favor of volleyball players ($p<0,05$).

Researchers are recommended to study with a sample which includes the variable of gender in a study conducted to find out the acute levels of exercise on serotonin and testosterone, to add elite/national team athletes in the sample, and to compare serotonin and testosterone levels with behavioural disorder tendencies by grouping the sedentary group within the group itself.

Trainers and athletes are recommended to show example behaviours to athletes with young ages about aggression/sportsmanship considering that athletes can learn aggressive behaviour through modelling, and trainers and athletes should be educated on aggression/sportsmanship by psychologists and expert educators in the field.

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