How to Cite:
Radhi, M. A., & Hadi, M. A. (2022). Effect of serotonin and thyroid stimulating hormone in criminal behavior of Iraqi males. *International Journal of Health Sciences*, *6*(S3), 7631–7642. https://doi.org/10.53730/ijhs.v6nS3.7766

Effect of serotonin and thyroid stimulating hormone in criminal behavior of Iraqi males

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***Abstract*---**Aim: Investigate the role of serotonin and thyroid stimulating hormone and their relationship with criminal behavior in Iraqi males prisoners. Method: A questionnaire was taken including the age, marital status, duration of imprisonment, residence, previous delinquency, educational level, and type of crime. Blood samples were taken from all of subjects involved in this study which was 80 (40 prisoners and 40 healthy control). All prisoners and control were from the same ethnic group (Arabic). Measurement of serotonin and thyroid stimulating hormone concentrations was performed for criminals and control groups. seR ults: The results showed that the 21-30 years age group of criminals prisoners were more frequent 17(42.5%) than control 3(7.5%) followed by age group 31-40 years which was 13(32.5%) compared to control 24(60%), whereas the percentage was 10 (25 %) in 41-50 years age group compared to control group 13(32.5%). According to educational level, most of the prisoners had no degree or at primary school 15(37.5%) followed by those with secondary school 10(25%) compared to the control group who had primary school 16(40%) was more frequent followed by university degree 11(27.5%) then secondary school 8(20%) and diploma degree 5(12.5%). According to the residence, most of the prisoners were in urban area 21(52.5%) than in rural area which was 19(47.5%) compared to control group which was 29(72.5%) and 11(27.5%) in urban and rural areas respectively. Moreover, according to marital status, most of criminals prisoners were married 24(60%) while singles were 16(40%) compared to control group in which the married persons were 29(72.5%) and singles was 11(27.5%).A ccording to the type of crime, both murders and drug abuse were 20(50%). The prisoners had previous delinquency were 15(37.5%) while 25(62.5%) without previous delinquency. The distribution according to their duration of imprisonment recorded that 6-10 years were 20 (33.3%) was more frequent. The mean of TSH concentration for all criminals prisoners was 2.04±0.23 µIU/L which nonsignificantly high (P>0.05)

Manuscript submitted: 27 March 2022, Manuscript revised: 18 April 2022, Accepted for publication: 9 May 2022

than control whereas serotonin concentration (78.39±6.77 ng/ml) was significantly elevated (P≤0.05) compared to control (62.73 ± 3.9 ng/ml) and serotonin non-significant positively correlated (r=0.1) with TSH. Conclusion: Both serotonin and TSH may had role in the criminal behavior of Iraqi prisoners.

***Keywords*---**serotonin, thyroid stimulating hormone, criminal behavior.

Introduction

Aggressiveness can be defined as the generation of a behavior that aims at causing physical or psychic harm to somebody else (Ferguson & Beaver, 2009). There is growing evidence that some individuals engage in both self-harm and aggression during the course of their lifetime (Shafti *et al.*, 2021) which provided support for the role of negative childhood experiences within the family, such as abuse, harsh discipline and early neglect, in aggression (Topitzes *et al.*, 2012; Milaniak and Widom, 2015). However, the genetic and neurophysiological mechanisms implicated in aggressive behavior and became evident that both social and environmental factors are not the only reasons explaining the development of aggressive and anti-social behavior (Mendes *et al.*, 2009). There are many neurotransmitters that have been implicated in emotional and crime related behavior (Glick, 2015). A number of studies indicate that serotonin or 5-hydroxytryptamine (5-HT) and dopamine (DA) systems interact closely at a basic neurophysiological level (Daw *et al.*, 2002). It is known that neurotransmitters control aggression but the mechanisms involved are still not clear (Rathore & Sarkar, 2021).

A monoamine neurotransmitter (5-HT) plays a role in several complex biological functions (David & Gardier, 2016) such as modulating mood, cognition, reward, learning, memory, and numerous physiological processes such as vomiting and vasoconstriction. Serotonin forms from the hydroxylation and decarboxylation of the tryptophan amino acid (Young , 2007). Serotonin induces changes in the cell by its action on the serotonergic receptors, which are coupled to different G proteins mediating intracellular changes (Smith & Smith, 2020). Also, 5-HT is a key neurotransmitter related to aggressive behavior. Serotonergic neurons originate from raphé nuclei in the brain stem. The relationship between serotonin and aggression is extremely complex. Different neural pathways can present different reactions depending on the receptor subtypes that are present in the pathway. There are seven known of 5-HT receptors: 5-HT1, 5-HT2, 5-HT3, 5-HT4, 5HT5, 5-HT6, and 5-HT7 (Celada *et al.*, 2013). Furthermore, serotonin has shown both inhibitory and stimulating effects on aggressive behavior, depending on the specific receptors where it acts (Narvaes and de Almeida, 2014).

Moreover, various factors cause aggression, which can be related to hormone imbalance T3 and T4, which can act as neurotransmitters are reported to be elevated during aggression. Moreover, mental and behavioral disorders possibly occur in individuals with impairment in thyroid hormone balance (Acar, 2018). Disorders of the thyroid gland are frequently associated with severe mental disturbances. There is intimate association between the thyroid system and behavior and the role of the hypothalamic-pituitary thyroid (HPT) axis in the pathophysiology of mood disorders. Thyroid hormones have a profound influence on behavior and mood (Bauer *et al.*, 2001; Whybrow & Bauer,2001). Furthermore, the thyroid has a modulating impact on the brain serotonin system. Thus it is postulated that one mechanism, through which exogenous thyroid hormones may exert their modulatory effects in affective illness is via an increase in serotonergic neurotransmission, specifically by reducing the sensitivity of serotonin receptor (5-HT1A), and by increasing 5-HT2 receptor sensitivity. Also, the thyroid status impacts the serotonin system in the adult brain and the increasing thyroid hormone levels increase serotonin neurotransmission (Bauer *et al.*, 2002).

Some studies aiming to clarify and control the biological basis of aggression. Thyroid hormones have been indicated to play a role in the development of aggression. The mean score of free T3 level in the criminal antisocial personality disorder (APD) group was found to be significantly higher than that in the noncriminal APD group. APD subjects with higher free T3 levels also had higher aggression scores (Evrensel *et al.*, 2016). In addition, the relation between thyroid function and depression has been recognized. Patients with hypothyroidism commonly manifest features of depression while hyperthyroidism presents with a wider spectrum of neuropsychiatric symptoms including both depression and anxiety (Hage and Azar, 2012). Also, aggression is among the symptoms of hyperthyroidism (Brandt *et al.*, 2013). The incidence of crime in individuals with high serum T3 levels is 3.8 times greater than that in those with normal serum T3 levels (Eklund *et al.*, 2005). There are very few studies that indicate a correlation between serum thyroid hormone levels and aggression and tendency to commit a crime in Iraq. Therefore, the aim of current study was to investigate the role of serotonin and thyroid stimulating hormone and their relationship with criminal behavior in Iraqi males prisoners.

Materials and Methods

Study design

The study subjects comprised 40 prisoners and the age-matched group control group comprised 40 apparently healthy individuals. The age of both prisoners and control groups ranged from (20-50) years. All prisoners selected from Iraqi prisons and samples collection was performed under appropriate ethical guidelines. All prisoners and control were from the same ethnic group (Arabic). The prisoners were asked to provide informations as questionnaire taken including their age, marital status, ethnicity, occupation, duration of imprisonment, residence, previous delinquency (aggression history), educational level, accusation type. The experimental design was shown in Figure 1.

Blood sampling

Five ml of blood were obtained from each prisoners and control groups by vein puncture by vein puncture and the pushed slowly into disposable tubes containing separating gel, then, blood was allowed to clot at room temperature for

(30) minutes and centrifuged at 2000 rpm for approximately (15) minutes then the sera were obtained and stored at (-20˚C) until analyses.

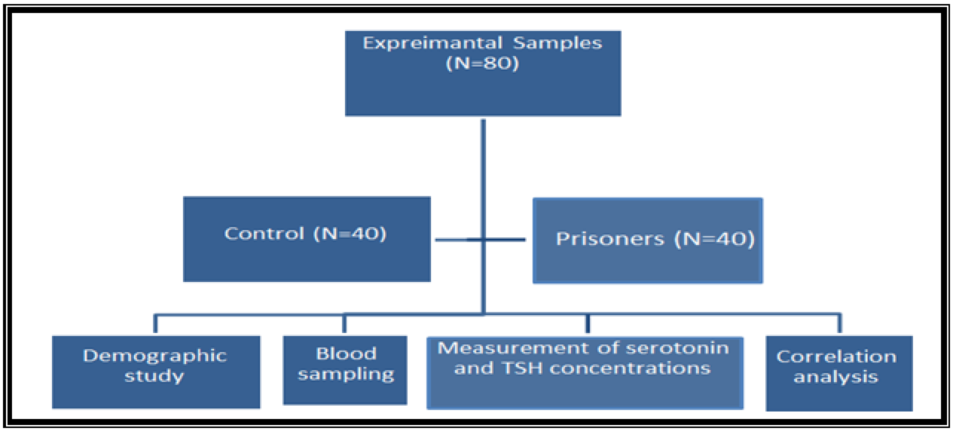

Figure 1. Experimental design

Measurement of serotonin and thyroid stimulating hormone concentrations

The human serotonin IBL International laboratory kit (Germany) components and human TSH SD Biosensor kit (Korea) was used to detect human serotonin and TSH concentrations in this study by the enzyme linked immunosorbant assay (ELISA) technique according to manufactures instructions.

Results

Distribution of study groups by socio-demographic characteristics

In this study, the distribution of Iraqi prisoners compared with control groups according to socio-demographic characteristics was showed in Table 1. The 21-30 age group of criminals prisoners were more frequent 17(42.5%) than control 3(7.5%) followed by age group 31-40 year which was 13(32.5%) compared to control 24(60%), whereas the percentage was 10 (25 %) in 41-50 years group compared to control group 13(32.5%). When separating the criminals prisoners according to educational level, most of them were had no degree 15(37.5%) or at primary school 15(37.5%) followed by those with secondary school 10(25%) compared to the control group in which who had primary school 16(40%) was more frequent followed by who had university degree 11(27.5%) then secondary school 8(20%) and diploma degree was 5(12.5%). According to the residence, it was found that most of them was in urban area 21(52.5%) than in rural area which was 19(47.5%) compared to control group which was 29(72.5%) and 11(27.5%) in urban and rural areas respectively.

Table 1
The demographic characteristics of study groups

Age group	control	prisoners	x2	Sig.*
21- 30	3(7.5%)	17(42.5%)	13.46	0.001

31- 40	24(60%)	13(32.5%)		
41- 50	13(32.5%)	10 (25 %)		
Total	40(100%)	40(100%)		
Educational level				
No degree*	0	15(37.5%)	31.25	0.000
Primary school	16(40%)	15(37.5%)		
Secondary school	8(20%)	10(25%)		
Diploma	5(12.5%)	0		
University	11(27.5%)	0		
Total	40(100%)	40(100%)		
Residence				
Urban	29(72.5%)	21(52.5%)	38.58	0.000
Rural	11(27.5%)	19(47.5%)		
Total	40(100%)	40(100%)		
Marital status				
Married	29(72.5%)	24(60%)	12.75	0.000
Single	11(27.5%)	16(40%)		
Total	40(100%)	40(100%)		

*P-value ≤ 0.05 was significant

Moreover, according to marital status, most of criminals prisoners were married 24(60%) while singles were 16(40%) compared to control group in which the married persons were 29(72.5%) and singles was 11(27.5%).

Distribution of criminals prisoners according to type of crime

The distribution according to their type of crime recorded that both murders and drug abuse were 20(50%) as shown in Figure 2.

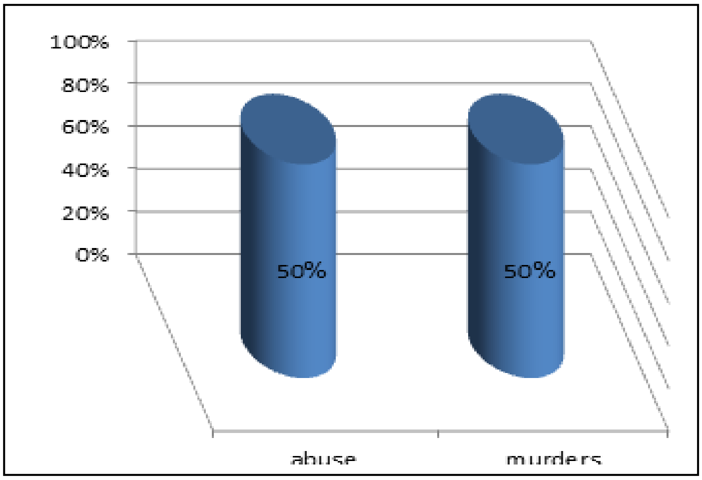

Figure 2. Distribution of criminals prisoners according to type of crime

Distribution of criminals prisoners according to previous delinquency and duration of imprisonment

Figure (3A) revealed that 15(37.5%) of prisoners had previous delinquency while 25(62.5%) without previous delinquency. The distribution according to their duration of imprisonment recorded that 1-5 years were 10 (25%), 6-10 years were 20 (37.5%),11-15 years were 11(27.5%) and for death was 4(10%) (Figure 3B).

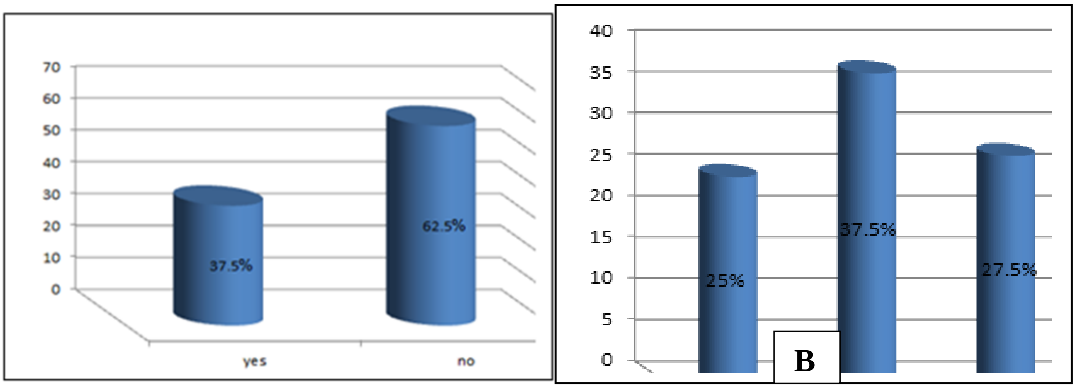

Figure 3. Distribution of criminals prisoners according to previous delinquency (A) and according to duration of imprisonment (B)

Mean differences of serotonin and TSH concentrations between study groups

The results in Table (2) showed that mean of serotonin concentration all prisoners (78.39±6.77 ng/ml) was significantly elevated ($P \leq 0.05$) compared to control (62.73 ± 3.9 ng/ml) whereas the mean of TSH concentration for all prisoners was 2.04± 0.23 µIU/L which nonsignificantly high ($P > 0.05$) than control (1.89 ± 0.17 µIU/L).

Table 2
Mean differences of serotonin and TSH concentrations between criminals prisoners and control groups

Group	Control (Mean ± SE)	Prisoners (Mean ± SE)	P- value
Serotonin (ng/ml)	62.73 ± 3.9	78.39±6.77	0.04*
TSH (µIU/L)	1.89 ± 0.17	2.04± 0.23	0.6

*P-value ≤ 0.05 was significant

When separating criminals prisoners according type of crime and comparing TSH and serotonin concentrations between them according type of crime, the statistical analysis revealed no significant differences between them ($P > 0.05$) as shown in Table (3).

Table 3
Mean differences of serotonin and TSH between subgroup of prisoners according to type of crime

Subgroup of prisoners	Murders (Mean ± SE)	Drug abuse (Mean ± SE)	P- value
Serotonin (ng/ml)	88.55 ± 10.7	68.23 ± 7.97	0.13

TSH (µIU/L)	2.17 ± 0.36	1.91 ± 0.29	0.58

*P-value ≤ 0.05 was significant

The correlation of serotonin with TSH in the study group

The results revealed that serotonin positively correlated with TSH (r=0. 1) but the correlation was non-significant as shown in Figure 5.

Discussion

In the current study, some of the demographical characteristics were assessed. The age group 21-30 years of criminals prisoners were more frequent 17(42.5%) followed by age group 31-40 which was 13(32.5%) then 10(25%) in 41-50 years. In particular, research has examined whether individuals who initiate their offending early in life are more likely to become long-term or high-rate offenders.

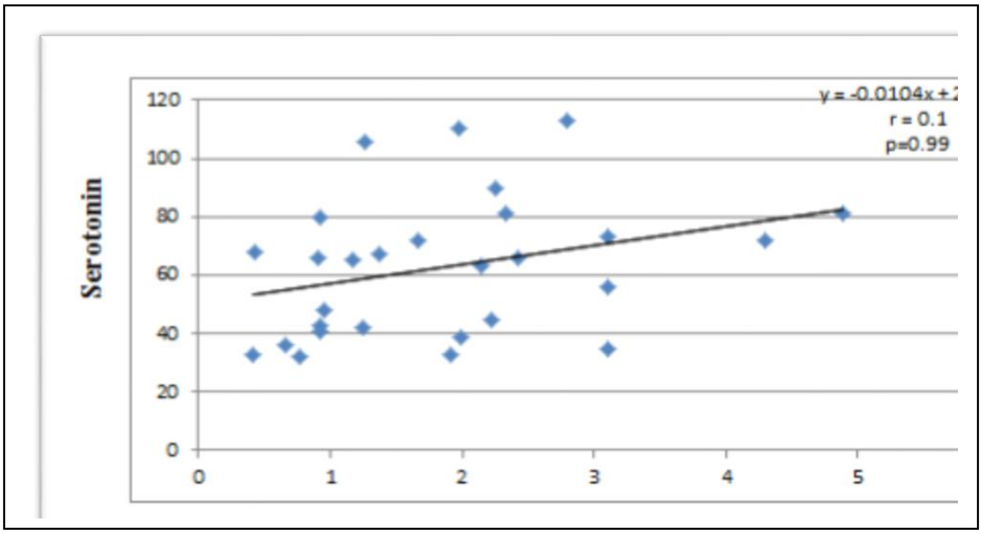

Figure 5. The correlation of serotonin with TSH was positively non-significant correlation

The result of current study non-compatible with previous studies that recorded that the prevalence of offending tends to increase from late childhood, peak in the teenage years (from 15 to 19) and then decline in the early 20 years (Piquero *et al.*, 2007) while another previous report which demonstrated that criminal activity peaks at age 17 and then gradually declines. However, criminologists have long observed a strong correlation between age and crime. It is necessary to include sociological, psychological, and environmental elements into the understanding of the age and crime relationship (Cornelius *et al.*, 2017). Age is confound in regard to changing response and actual levels of hormones particularly testosterone. There is evidence that testosterone levels are higher in individuals with aggressive behavior, such as prisoners who have committed violent crimes (Batrinos, 2012; Al-Shwaliy, 2019). Previous Iraqi study elucidated the role of genetic polymorphisms in androgen receptor (AR) gene and testosterone concentration in violence behavior and criminal activity in Iraqi prisoners males and included extraction of DNA from blood samples taken from 60 Iraqi criminal prisoners (aged 17–70 years) in addition to 30 age and sex-matched healthy control group then amplifying the androgen receptor *(AR*) gene and detection sequencing of *AR* gene (exon 1). Furthermore, the statistical analysis of testosterone concentration revealed significant increasing (P≤0.05) in criminal prisoners group compared to the control group. According to the sequencing results of *AR* gene (exon 1), the molecular study recorded that CAG repeat, a genetic trait marker associated with AR function and aggression were replaced by CTG repeats in Iraqi population. Moreover, the presence of some SNPs in sequenced region were recorded. These CTG repeats and SNPs may be reflected in 3 dimensional structure of AR protein then its function (Al-Shwaliy, 2019).

In fact, the age distribution for all crimes is not the same, and that social factors are likely to be useful in explaining such things as onset, frequency, duration, and desistance from crime. The relationship between age and crime is one of the most robust relationships in all of criminology. This relationship shows that crime increases in early adolescence, around the age of 14, peaks in the early to mid-20s, and then declines thereafter (Rocque *et al.*, 2016). According to the residence, it was found that the percentage of prisoners more frequent in urban area 21(52.5%) than in rural area that may be due to a powerful relationship between residing in a different environment and participating in criminal acts (McCord *et al.*, 2001). According to educational level of the criminals prisoners, most of them were had no degree 15(37.5%) or at primary school 15(37.5%) followed by those with secondary school 10(25%) but decrease in higher educational level. Moreover, according to marital status, most of criminals prisoners were married 24(60%) while singles were 16 (40%). This increasing in married may due to prisoners face conviction at some point during their lives according to van Schellen *et al.* (2012) study which revealed that marrying a spouse with a criminal history fails to decrease criminality among individuals who face conviction at some point during their lives. This result didn't agree with result of Andersen *et al.*, (2015) who suggested that an apparent relationship between marriage and reduced offending and their findings not only underline how important marriage is for social integration but also stress the heterogeneous nature of the protective effects of marriage. Further, marriage is often considered an important lever for criminal desistance, especially among men (Sampson *et al.*, 2006).

According to aggression history, 15(37.5%) of prisoners had previous delinquency while 25(62.5%) without previous delinquency. Herrenkohl and colleagues (2001) noted that the problems at school can lead to delinquency and children with low academic performance, low obligation to school, and low educational aims during the primary and secondary school grades are at higher risk for child delinquency than other children. Sampson and Laub (2003) identify graduating from high school or college, serving in the military, getting married, or having children as turning points in life that directly alter one's route. Further, these turning points can result in a trajectory away from criminality as crime is often not conducive to the achievement of each of these turning points .

Previous reviews revealed that the social inequality, poverty and the environment familial dysfunction, family criminality, educational underachievement, child abuse, crime and antisocial behavior at childhood are significant risk-factors for aggression and the main reasons for the display of an aggressive and criminal behavior. The interaction between biological and environmental factors can be catalyzed by a hostile environment, thus increasing the risk for the development of aggressive behavior (Mendes *et al.*, 2009). The results revealed a significant increasing in the mean of serotonin concentration in prisoners compared to control groups (Table 2). Also, the mean of serotonin concentration had nonsignificant differences between prisoners subgroups when divided according to type of crime as shown in table (3). This result may due to that neurotransmitters molecules (5-HT and DA) which are key factors in a wide range of behaviors are involved not only in aggressive behavior but also in coping with stress. Both pleasant and stressful events activate the mesocorticolimbic dopamine system (Miczek *et al.*, 2004).

The results of current study didn't agree with previous study showing that people with low serotonin concentration are aggressive in nature (Rathore & Sarkar, 2021). Beitchman *et al.* (2006) evaluated the association of polymorphisms in the transporter gene of serotonin and aggressive behavior at both infancy and adolescence aged between 5 and 15 years who were genotyped for the serotonin transporter gene polymorphism (5HTTLPR) and the 5-hydroxytryptamine transporter (5HTT) variable-number-tandem-repeat polymorphisms. The presence of alleles with a low genic expression in the transcription control site in 5-HTTLPR (S/S, LG/S, Lg/Lg) was strongly associated to a risk twice as large of aggressiveness at infancy compared to individuals with high expression alleles (n = 77, p = 0.049, OR = 2.37, CI = 1.10-5.8). Similar results were shown by Haberstick *et al.* (2006) who conducted that the allele S-5HTTLPR was associated to high levels of aggressive behavior in school-aged children. Other studies have established the same association with aggressiveness at adulthood (Retz *et al.*, 2004) thus leading to the conclusion that the presence of low expression alleles in adults is indeed associated with extreme violence (Mendes *et al.*, 2009).

The relationship between serotonin hypofunction and impulsive aggression is a consistent finding in clinical neuroscience. In relation to this, dopaminergic hyperactivity may exert an additive effect on proneness to aggressive behavior, that is, secondary to serotonergic dysfunction. Given that the serotonergic system modulates dopaminergic activity, hyperactivity in the dopamine system in aggressive individuals may be attributed to disinhibition of the dopamine activity from deficient serotonergic function (Seo *et al.*, 2008). Previous Iraqi study had determined the changes in concentrations of the neurotransmitter dopamine and some micronutrient their relationship with criminal behavior in criminal Iraqi prisoners who including 46% appointed as drug-abuse and trading, 33.33% of them were murders and 20% were appointed as terrorisms criminals. The results revealed presence of significant increase ($P \leq 0.05$) in dopamine, zinc, iron, and magnesium concentrations in criminals group compared to healthy control group (Abdullah, 2019).

The results revealed non-significant increasing in the mean of TSH concentration in prisoners compared to control groups (Table 2) which mean decreasing in T3 &T4. Thyroid hormones have been indicated to play a role in the development of aggression. The results of current study disagree with previous studies which recorded that the mean score of free T3 level significantly higher with higher aggression scores in the criminal antisocial personality disorder (APD) group than that in the noncriminal APD group (Evrensel *et al.*, 2016). Furthermore, the crimes were 3.8 times more frequent in juvenile delinquents with high T3 levels than in those with low T3 levels. The mean TSH levels did not differ between crime groups. Also, significantly more frequent substance-alcohol abuse, self-mutilation, tattoos, and suicide attempts as well as significantly lower levels of education were found in the violent offenders group. The free T4 and cortisol levels of the case group were found to be significantly higher than those of the control group, whereas the free T3 level was lower (Eklund *et al.*, 2005). Moreover, the association of thyroid hormone levels, TSH, T3/T4 ratio and presence of toxic goitre with crime type in prisoners was recorded. This indicates changes in the hypothalamic-pituitary-thyroid axis that cause long-term changes in aggressive behaviour, especially in criminals (Acar, 2018).

Furthermore, the results revealed that serotonin positively correlated with TSH (r=0. 1) but the correlation was non-significant. The receptors studies indicate that thyroid hormone application may increase cortical 5-HT2 receptor sensitivity. The interaction of the 5-HT system and thyroid axis function was investigated in patients with major depression and indicate that an experimentally-induced hypothyroid state in adult rodents is associated with decreasing in cortical 5-HT serotonin concentrations and 5-HT2A receptor density (Bauer *et al.*, 2002). This interaction of thyroid hormones with the serotonin system is probably only one of the mechanisms through which thyroid hormones may have modulatory effects in mood disorders. Thyroid hormones interact with a broad range of neurotransmitter systems thought to be involved in the regulation of mood including post-receptor and signal transducing processes, as well as gene regulatory mechanisms. In addition to the important role of the serotonin system in the pathogenesis of depression, the serotonin system may be involved in the mood modulating effects of thyroid hormones among patients with affective disorders (Bauer *et al.*, 2002).

Conclusion

The serotonin system and TSH may be involved in the modulating effects of thyroid hormones in criminal behavior.

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