Journal of Applied and Natural Science
13(2): 571 - 584 (2021)
Published online: June 2, 2021
ISSN : 0974-9411 (Print), 2231-5209 (Online)
journals.ansfoundation.org

Review Article

Progression of anorexia nervosa: An insight into neurological and biological mechanisms influencing the personality patterns of anorexics

Aatma Singh*
Department of Home Science, Lyallpur Khalsa College for Women, Jalandhar-144008 (Punjab), India
Kiran Bains
Department of Food and Nutrition, College of Community Science, Punjab Agricultural University, Ludhiana-141004 (Punjab), India
Harpreet Kaur
Department of Food and Nutrition, College of Community Science, Punjab Agricultural University, Ludhiana-141004 (Punjab), India

*Corresponding author. Email: aa_singh8@yahoo.com

Article Info
https://doi.org/10.31018/jans.v13i2.2495
Received: January 15, 2021
Revised: May 20, 2021
Accepted: May 25, 2021

How to Cite
Singh, A. *et al.* (2021). Progression of anorexia nervosa: An insight into neurological and biological mechanisms influencing the personality patterns of anorexics. *Journal of Applied and Natural Science*, 13(2), 571 - 584. https://doi.org/10.31018/jans.v13i2.2495

Abstract
Anorexia nervosa has emerged as a prominent eating disorder affecting young women. This disorder's fundamental characteristic is an abnormally low weight achieved by severe calorie restriction and refusal to maintain body weight at or above the minimally normal weight for age and height. It is a complex disorder with its origins still not explicitly defined. In anorexic individuals, an imbalance in the molecular signalling and hypothalamic neuropeptides is believed to be significantly responsible for alterations in the biological mechanisms associated with body weight, appetite and energy homeostasis. The imbalance between the genetic systems such as serotonin, dopamine, brain-derived neurotrophic factor, estrogen and their interactions are significantly observed in anorexic as well as recovered anorexic individuals. The dopaminergic pathway is involved in reward mechanisms but its dysfunction might cause weight loss, food aversion, hyperactivity, obsessive compulsive behaviours, distorted body image. An abnormal serotonin function reveals personality traits such as rigidity, inhibition, anxiety, inflexibility, perfectionism and harm avoidance. The Met66 variant of brain derived neurotrophic factor is strongly associated with the development of restricting-type anorexia nervosa. The development of anorexia has been linked to estrogen receptor beta gene variants, which also regulate food intake and states of anxiety and depression.This review discusses the neurobiological dysregulations because of which anorexics tend to have a distinct personality profile characterized by behaviour patterns comprising perfectionism, obsessive-compulsive disorder, harm avoidance, alexithymia, anger suppression, anxiety, rigidity, novelty seeking, anhedonia, depression, impulsivity, substance abuse, self harm etc. Heterogeneities in the characteristic profile are observed based on the subdivisions of anorexia nervosa. The impact of malnutrition has also been scrutinized.

Keywords: Anorexia nervosa, Eating disorders, Personality disorders, Genetics Perfectionism

INTRODUCTION

Anorexia Nervosa (AN) is a multifaceted disorder characterized by an inappropriate weight loss due to psychological and behavioural abnormalities. According to the fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV), AN is defined as a failure or denial to maintain body weight >85% of which is expected for height (corresponding to body mass index (BMI), extreme fear of gaining weight, disturbed perception of body weight/shape and the occurrence of amenorrhea for a minimum of three consecutive months. However, DSM-V made three alterations in the diagnostic criteria for AN: revision of weight loss criterion, i.e., 'A weight that is less than minimally normal or, for children and adolescents, less than that minimally expected' (Mustelin *et al.*, 2016); if behaviours hindering weight gain are observed then the fear of weight gain need not be verbalized and amenorrhea was now not required in the diagnosis (APA, 2013). AN has further two subtypes: (i) the restricting subtype, characterized by a very limited food intake or dieting; (ii) the binge/purge subtype, characterized by restraint on food intake to lose weight followed by an episode of binge eating and subsequent purging (self-induced vomiting/ laxative abuse).

In general, eating disorders incidence rate is generally expressed as per 100,000 persons per year (Smink *et al.*, 2012) and prevalence is the proportion of a population which is predisposed to the disorder at a specific point of time, for instance, at a certain date (point prevalence), in a certain year (12-month prevalence; often used in the DSM-5), or at any point in life (lifetime prevalence). Researchers have often observed women to be more liable to the risk of developing eating disorders and their associated symptoms as compared to men. The occurrence of anorexia nervosa in the general population is approximately 0.3% (Hoek, 2006) though nine females are affected for every male. 0.9% of females are observed to be anorexic (Hudson *et al.*, 2007) with sub-threshold levels prevalent up to 2.4% (Wade *et al.*, 2006). AN is a complex and relapsing disorder with a higher risk of premature death on comparison to normal healthy population.

Anorexia nervosa is a complex disorder with its origin still not specifically explained but is supposed to occur due to various reasons. According to Klump and Culbert (2007, conventionally, the major causative agents for the development of eating disorders were supposed to be psychosocial factors but twin studies revealed, more than half (58-83%) of the risk in the development of an eating disorder lies in the genetic setup of an individual. Environmental factors have also been observed to influence the risk of developing anorexia which includes childhood sexual abuse, female gender, dieting, early childhood eating and digestive problems (Jacobi *et al.,* 2004). Psychological factors such as the presence of anxiety, obsessive-compulsive disorder, depression, attention deficit hyperactivity disorder and substance abuse (Rikani *et al.,* 2013). Clinical observation has long suggested a link between personality and eating disorders. Eating is basically a rewarding behaviour, and is thus innately related to personality traits, emotions and moods (Vögele and Gibson, 2010).

In the clinical setting, personality disorders are commonly encountered in individuals predisposed to eating disorders (Sansone and Sansone, 2011). According to APA (2013), the essential features of a personality disorder are “impairments in personality (self and interpersonal) functioning and the presence of pathological personality traits” (DSM-V). These symptoms are highly noticeable in the aspects of interpersonal execution, cognition, affectivity and impulse control. Personality traits have been found to influence the onset, symptomatic features and continuance of eating disorders (Cassin and Ranson, 2005). The personality disorders mentioned in DSM are broadly classified into three primary clusters. Cluster A refers to the first classification or subtypeto those personality disorders characterized by odd or eccentric features. Cluster B, the second subtype refers to the personality disorders characterised by dramatic and erratic features. The third subtype, Cluster C refers to the personality disorders characterised by anxious or inhibited features. Generally, eating disorders are found to overlap personality disorders.

Genetics

Extended researches have concluded eating disorders as significantly heritable causing altered brain activity as well as in certain cases impaired cognitive function, decisions and emotional stability. Genetic studies have explored and revealed chromosomal sites and genes which predispose an individual to the risk of developing a specific eating disorder. Genes concerned with serotonin (Bergen *et al.,* 2003; Klump *et al.,* 2007), opioid systems (Bergen *et al.,* 2003) and brain-derived neurotrophic factor (Klump *et al.,* 2007; Ribases *et al.,* 2004 & 2005) might contribute to the risk for developing anorexia nervosa whereas chromosomal sites 1, 4 and 10 might hold risk genes for both anorexia and bulimia nervosa (Grice *et al.,* 2002). It was also noted that in anorexic individuals even after recovery from illness (Kaye *et al.,* 2001 & 2002) disordered functioning of brain serotonin (Kaye *et al.,* 2005; Steiger *et al.,* 2005), neuro-circuitry (Uher *et al.,* 2003; Wagner *et al.,* 2007 & 2008) and neuropeptide systems (Kaye *et al.,* 2005) continued. The below stated genes are involved in the modulation of metabolism, appetite, autonomic and hormonal systems, cognition, impulse control and mood.

Dopamine

There are certain characteristic traits of anorexic individuals portrayed as being anhedonic, ascetic and are often observed to have compulsive exercise regimens (APA, 1994). Above all, they derive a sense of reward and satisfaction from the pursuit of weight loss rather than any other experience. Even after recovery such traits exist but to a mild extent (Klump *et al.,* 2004). This reflects that these specific characteristics are not state related but are traits of that specific individual. Frank *et al.,* (2005) demonstrated that in anorexic individuals a distorted state of reward and affect, executive control, certain motor movements and reduced appetite were associated to abnormal functioning of dopamine system especially in the striatal circuit of the brain. Kaye *et. al* (1999) also noted that reduced CSF concentration in DA metabolites is found in both anorexic and also in recovered anorexic individuals. Ventral striatum is the region of the brain involved in reward mechanisms and responses in which the levels of D2/D3 receptor (DRD3) increased in recovered anorexics (Kaye *et al.,* 1999; Montague *et al.,* 2004). Moreover, D2/D3 receptor binding potential in the dorsal caudate and putamen regions of the brain is significantly correlated with harm avoidance in recovered anorexics (Frank *et al.,* 2005). Wagner *et al.,* (2007) conducted an event based fMRI study to compare diverse re-

sponses to reward in both recovered anorexic and healthy controls through the collection of blood oxygen level dependent (BOLD) signal when participants performed a 'guessing-game' which is known to stimulate the ventral striatum and subgenual anterior cingulate cortex (ACC). It was observed that healthy controls revealed different activities in both brain regions in response to the negative and positive feedbacks whereas the recovered anorexics revealed similar activities in both regions of their brain, indicating that anorexics have circuit-based abnormality, which might contribute to difficulty in differentiating between positive and negative feedbacks (Wagner *et al.,* 2007). Dopamine plays a significant role in regulating motivational mechanisms in the ventral striatum to stimuli as it alters the influence of limbic inputs on striatal activity (Schultz *et al.,* 2004; Wagner *et al.,* 2007). Recovered anorexics have a failure to aptly bind, regulate or differentiate responses to stimuli through ventral straital regions of the brain. This suggests that recovered anorexics might have an impaired capacity to understand the emotional implication of the stimuli (Phillips *et al.,* 2003) thus indicating their restraint in engaging in treatment (Halmi *et al.,* 2005). Recovered anorexic women had exaggerated activation of caudate-dorsal striatum and in cortical regions projecting in this region especially dorsolateral prefrontal cortex (DLPFC) and the parietal cortex (Wagner *et al.,* 2007). The tasks involving both actions and outcomes along with unpredictability about whether a certain action will lead to a desired outcome is controlled by the caudate nucleus. A greater activation of the caudate nucleus was observed in women involved in strategic responses as opposed to hedonic ones. As a result, inappropriate reward processing through ventral-striatal/DA pathways causes recovered anorexics to put emphasis on detailed strategy rather than the overall scenario (Lopez *et al.,* 2008). The study revealed that the healthy control women actually 'lived in the moment' as they understood they had to guess the response and move on to the next task. However, anorexic individuals were observed to dwell and obsess more about the result of their behaviour, searching for 'rules' which were not mentioned and were overly critical of committing mistakes. Another study using fMRI imaging based on a standard shifting task had similar revelations in anorexic individuals demonstrating hypo-activation in the ventral anterior cingulate-striato-thalamic loop with stimulation of fronto-parietal networks. Thus the data reveals that anorexic individuals are less likely to be able to regulate affective response to immediate significant stimuli rather, they have exaggerated activity in their neuro-circuits involved in planning and consequences. The dopaminergic pathway is involved in reward mechanisms but its dysfunction might cause weight loss, food aversion, hyperactivity, menstrual dysfunction, obsessive compulsive behaviours, distorted body image specifically during increased dopaminergic activity (Kaye, 2007).The neuro-circuits involved in planning and consequences exhibit an increased activity as anorexics are highly detail oriented and is reflected through their obsessive and compulsive tendencies. In recovered malnourished anorexic individuals, decreased concentration of dopamine metabolites in cerebrospinal fluid occurs (Kaye *et al.,* 1999). Therefore, dopamine deregulation might influence the reward and affect pathways, decisions, frequent motor activities and decreased ingestion of food in anorexia (Halford *et al.,* 2004).

Serotonin (5-HT)

Control of appetite, sleep, memory, mood and learning are all regulated through a neurotransmitter called serotonin. The 5-HT neurotransmitter system has been intensively linked to certain symptoms such as impulse control (Fairbanks *et al.,* 2001), satiety (Tierney, 2020) and mood (Lesch and Merschdorf*,* 2000). Extensive data reveals eating disorders are strongly linked to the disturbances in serotonin gene system. Various evidences reveal a strong association between altered activity of the 5-HT system and the development of AN (Kaye *et al.,* 2005). The two most important serotonin genes involved in eating disorders are the serotonin 1a & 2a receptors and the serotonin transporter gene (5-HTT). Indeed, it is observed that emaciated and malnourished individuals suffering from anorexia nervosa, have reduced concentration of 5-hydroxyindoleacetic acid (5-HIAA) a brain metabolite thought to reflect the extracellular 5-HT concentrations in the cerebrospinal fluid (Coplan *et al.,* 2014). Inversely, in individuals recovered from anorexia the 5-HT metabolite concentration increases in the cerebrospinal fluid (Kaye *et al.,* 2009). A range of studies demonstrated the enhanced binding capacity for 5-HT_{1A} receptors and reduced binding potential for 5-HT_{2A} receptors in individuals who recovered from eating disorders (Frank *et al.,* 2002; Kaye *et al.,* 2007; Audenaert *et al.,* 2003). Trait-related alterations of 5-HT function are found to exist in anorexic individuals. Several evidences also predict significant association of the serotonin system with specific anorexic traits such as rigidity, perfectionism and obsession. Brain imaging researches have indicated an important link in abnormal 5-HT function and dysphoric mood seen in anorexia (Frank *et al.,* 2001; Kaye *et al.,* 2003). Also, brain imaging studies express a positive and significant association between the binding capacity of both 5-HT_{1A} and 5-HT_{2A} receptors and the characteristic trait of harm avoidance which includes inhibition, anxiety and inflexibility. These two receptors have also been observed to have an association in anxiety issues demonstrated through a range of animal and human studies (File *et al.,* 2000; Tauscher *et al.,* 2001; Weisstaub *et al.,* 2006; Moresco *et al.,*

2002). In the frontal cortex and other cortical regions in rodents an increased (80%) co-localization of 5-HT_{2A} and 5-HT_{1A} postsynaptic receptors occurs. Mediation through interneuron causes direct hyperpolarizing and depolarizing of 5-HT on the prefrontal neurons which further project to the cortical and sub-cortical brain regions (Santana *et al.,* 2004; Carli *et al.,* 2006). Regulation of impulsivity, anxiety, attention functioning (Winstanley *et al.,* 2003) and discovering new environments are thought to be modulated through these interactions between 5-HT_{1A} and 5-HT_{2A} receptors in the medial prefrontal cortex (mPFC) and related areas. Serotonin re-uptake inhibitors are a treatment component in anorexia (Kaye *et al.,* 1991). Variations in 5-HTT function might cause distinct behavior of impulse control thus indicating the reason for anorexic individuals developing the restricting type AN rather than bulimic type AN although 5-HTT concentrations in AN and AN-BN subgroups are almost similar to healthy controls but distinct variations arise when AN and AN-BN subgroups are compared (Bailer *et al.,* 2007). However, recovered anorexics also reveal continuous 5-HT disturbances (Kaye *et al.,* 2009). This indicates that abnormal functioning of 5-HT system could be a biological marker for eating disorder.

Serotonin-Dopamine interactions

Daw *et al.* (2002) and Cools *et al.* (2008) hypothesized that 5-HT system might be a crucial antagonist to the DA-based appetitive responses. In animal studies the significance of 5-HT is brought to light through the conditioning of animals to various aversive experiences (Bari *et al.,* 2010) which might cause the relay of negative response signals even for related future dangers and threats (Daw *et al.,* 2002; Cools *et al.,* 2008). Animal studies bought it to light that DA neurons are inhibited by the 5-HT_{2C} receptors (Di Matteo *et al.,* 2004). An altered abnormal interaction between ventral and dorsal neuro-circuits might be due to an imbalance between DA and 5-HT pathways. Interestingly, other studies also suggest that diverse effects in the ventral and dorsal striatal circuits in regard to delayed reward in action choice are observed because of the 5-HT system functions in mutual opponency with DA system (Schweighofer *et al.,* 2007; McClure *et al.,* 2004). Anorexic individuals are often observed to exhibit inhibitory reactions and responses in place of motivation and reward (Kaye *et al.,* 2009). Medications with selective serotonin re-uptake inhibitors (ssRIs) reveal minute effects in terms of betterment of moods as well as decreased symptoms of eating disorders (Attia *et al.,* 2005).

Brain Derived Neurotrophic Factor (BDNF)

The brain-derived neurotrophic factor is a protein that regulates development, differentiation and continued existence of new and old neurons in the brain. BDNF influences food intake as its increased concentration is linked to suppression of appetite and loss of weight and vice versa (Hashimoto *et al.,* 2005). Many variations of BDNF gene exist, specifically the Met66 variant, is strongly associated with the development of restricting-type anorexia nervosa (Ribases *et al.,* 2003). Met66 variant gene has also been highly associated with harm avoidance, anxiety and depression (Jiang *et al.,* 2005). This reveals the neuro-physiological mechanisms involved, thus explaining the cautious characteristic profile of restrictive anorexics including low novelty seeking, reluctance to indulge in new activities in order to avoid harm and risks.

Estrogens

Estrogen has a significant role in eating behaviour as it highly influences appetite and its disturbance is linked to the development of eating pathology in women (Elder *et al.,* 2007). In fact, disordered eating initiates after puberty, during which ovarian hormones stimulate in girls. The development of anorexia has been linked to variants of estrogen receptor beta gene, which also regulates food intake as well as states of anxiety and depression (Walf & Frye, 2006). A range of data from twin studies reveals genes have a vital role in the initiation of eating pathology. Serotonin, estrogen and BDNF systems significantly influence appetite regulation. These systems might influence food intake independently or could be dependent on estrogen system for regulation. Gene transcription (a phenomenon where the DNS gene sequence is imitated into messenger RNA) within serotonin and BDNF systems occurs through estrogen gene expression. Gene transcription of estrogen for tryptophan hydroxylase (an enzyme regulating conversion of tryptophan to serotonin) and 5-HT_{2A} is specifically strong (Shively & Bethea, (2004); Norton & Owen (2005), respectively) while influencing 5 -HTT transcription (Shively & Bethea, 2004). The BDNF and serotonin systems demonstrate variations in functionality in both genders, although risk of eating pathology initiates after puberty (Klump *et al.,* 2003). Moreover, estrogen levels are prominent in females, thus it also plays an essential part in influencing neurobiological and genetic mechanisms which could lead to the development of eating pathology. According to Westen & Harnden-Fischer (2001) individuals diagnosed with the same eating disorders could reflect highly diverse personality characteristics, which might significantly affect the eating pathology outcomes.

Role of satiety and starvation

In anorexic individuals, dietary restraint is linked to anxiety and dysphoric mood to intake (Strober, 2005). A possible inter-relation between altered 5-HT function and dietary restraint as well as anxiety might occur in

anorexic individuals. It is well documented that carbohydrate intake raises extracellular 5-HT concentrations in the brain due to a series of metabolic effects on the amino acid precursor of 5-HT i.e., tryptophan (Kaye *et al.,* 2003). According to Kaye *et al.* (1991) increased extracellular brain 5-HT secretions are observed in anorexic individuals with ingestion of a normal amount of food both premorbidly and after recovery from anorexia. The increased 5-HT concentrations reduce food intake due to the activation of 5-HT_{2c} receptors (Simansky *et al.,* 2004). It has also been demonstrated that enhanced 5-HT_{1A} binding potential is significantly related to harm avoidance in anorexic individuals after recovery (Bailer *et al.,* 2005). Moreover, harm avoidance and anxiety disorders occur before and even after recovery from anorexia. Kaye *et al.,* (2009) proposed that harm avoidance and anxiety traits exist due to carbohydrate-induced increases in extracellular 5-HT levels through activated 5-HT_{1A} receptors, thus contributing to feeding dysphoric mood. On the contrary, when anorexic individuals starve, the extracellular concentrations of 5-HT might be reduced causing short relief from dysphoric mood. It has been demonstrated that dietary restraint, which consequently lowers the concentration of plasma tryptophan and experimentally decreased or depleted tryptophan decreases 5-HT formation in the brains of both animals and humans (Van *et al.,* 2011).In fact, lower concentrations of plasma tryptophan are also observed in weak and malnourished anorexic individuals (Attia *et al.,* 2005) as well as decreased 5-HIAA levels (Kaye *et al.,* 1988). Moreover, experiment-induced alterations with the objective to reduce tryptophan in the brain also reduce levels of anxiety in both anorexic and recovered anorexic individuals. 5-HT_{2A} receptor binding is positively related to harm avoidance in anorexic individuals. Kaye *et al.,* (2009) has well demonstrated that a relative increase in 5-HT extracellular concentration in the brain is observed when anorexic individuals are forced to eat, which consequently intensifies the dysphoric mood. As a result, anorexic individuals might prefer to stay in a state of starvation to avoid intake-induced dysphoric feelings.

Malnutrition a risk factor for development of AN

Profound neurochemical changes occur which could influence the pre-morbid traits accumulating symptoms that could sustain or further enhance the state of morbidity (Kaye *et al.,* 2009). It has been observed that anorexic individuals have distorted regulation in temporal, frontal, cingulate and parietal regions (Kaye *et al.,* 2006) and reduced brain volume (Lucas *et al.,*2000). Such disturbances normalize after weight gain which clearly indicates that these could be a consequence rather than the cause of anorexia (Kaye *et al.,* 2009). These consequent alterations that arise in anorexia are hormonal and metabolic in nature and attempt to either conserve energy or stimulate hunger (Schwartz *et al.,* 2000). Another atypical complication of anorexia nervosa is clinically significant hypoglycaemia. Leptin is a protein encoded by ob gene expressed in the adipocytes and helps regulate eating behaviour via central neuro-endocrine mechanisms. Serum leptin levels correlate with weight and percent body fat in normal and obese individuals, though it is unknown whether the regulation of leptin is normal below a critical threshold of body fat in chronic under-nutrition. Calandra *et al.* (2003) also examined the serum leptin levels in women aged between 15-36 years predisposed to anorexia nervosa. The data indicated that serum leptin levels are reduced in low body weight and percent body fat in anorexic patients as compared to controls.It was concluded that leptin levels strongly correlate with weight, body fat percent, and insulin like growth factor-I in anorexic patients, suggesting that leptin's physiological regulation is maintained in relation to nutritional status even at an extreme of low weight and body fat. In addition, anorexic individuals are found to have abnormal concentrations of corticotrophin-releasing hormone (CRH), cholecystokinin, neuropeptide Y (NPY), beta-endorphin and pancreatic polypeptide (Inui, 2001) and these altered concentrations directly influence and cause alterations in an individual's cognitive functions, moods, impulse control as well as the autonomic and hormonal systems (Jimerson,and Wolfe, 2006). These might be related to the behavioural and psychological symptoms and patterns observed in anorexia. For instance, various physiological and behavioural disturbances linked to anorexia such as altered emotionality, hyperactivity, hypothalamic hypogonadism, reduced sexual activity and decreased feeding behaviour were observed when intracerebroventricular CRH was administered in experimental animals (Kaye *et al.,* 1987). According to Kaye *et al.,* (2009) certain secondary manipulations as in peptide concentrations might continue to sustain anorexic behaviours through an aim for excessive dieting and weight loss. Furthermore, individuals that meet the diagnostic criteria for major depression, obsessive-compulsive disorder or other anxiety issues (Kaye *et al.,* 2004; Godart *et al.,* 2007) were associated with exaggerated emotional disturbances caused due to malnutrition (Kaye *et al.,* 2009). Researchers have observed that even after long-standing recovery from anorexia, certain behavioural and psychological traits still continue such as harm avoidance, perfectionism, negative emotionality, desire for thinness and mild diet related anxiety. These symptoms could be a cause of chronic malnutrition and indeed the patterns (Wagner *et al.,* 2006) observed above are much related to those explained for the children who are at risk of developing anorexia (Stice, 2002; Anderluh *et al.,* 2003) indicating that these underlying traits could

lead to the initiation of this disorder.

Neurobiological processes and behavioural patterns in anorexia nervosa

Anorexia nervosa has emerged as a prominent eating disorder affecting young women. The fundamental characteristic of this disorder is an abnormally low weight achieved by severe calorie restriction and refusal to maintain body weight at or above the minimally normal weight for age and height. This behaviour is manifested as a relentless pursuit for thinness, a morbid fear of fatness or weight phobia. The patient is often observed to deny the complications that might arise due to low weight. These patients exhibit persistent obsession with dieting and weight loss which causes severe emaciation and in certain cases proves fatal. It is unclear whether these symptoms are consequence of anxiety or obsession disorder or reflect an underlying disturbance of brain appetitive circuits. The behavioural patterns such as inhibition, anxiety, depression, obsession, body shape distortion, perfectionism and anhedonia could be determined though the neuromuscular and cognitive pathways that control and adapt the processes related to appetite, emotionality and cognition.

Anorexia nervosa is further classified into restricting and binge eating/purging types based on the presence or absence of binging or purging. Patients generally move between these two sub-divisions. Generally, it occurs in adolescence but the age of onset can range from pre-adolescence to middle age. Eating disorders consequently lead to physical and psychological morbidity in adolescent girls and young adult women. Adolescence is considered a crucial phase in the risk of developing eating disorders because of the convergence of both psychological and physical challenges. These disorders are much less frequent in men. The longitudinal study followed up 800 children at three time points suggested that concerns related to body shape and weight develop through childhood, becoming common by later adolescence, particularly in girls. It is the psychological impact that is most powerful in promoting eating disturbance (Voelker *et. al*, 2015).

A large number of researches have indicated that personality disorders (PDs) recurrently occur with eating disorders in both clinical and community samples (Bornstein, 2001). Cluster C PDs (obsessive-compulsive, dependent, avoidant) are most frequent in individuals with eating disorders, followed by Cluster B (borderline, histrionic, narcissistic, anti-social) and Cluster A (paranoid, schizoid, schizotypal) (Johnson & Wonderlich, 1992). Meta-analysis conducted by Bornstein (2001) revealed that personality disorders most associated with anorexia were avoidant (53%), dependent (37%), obsessive-compulsive (33%) and borderline PD (29%) whereas in bulimia nervosa borderline (31%), dependent (31%) and avoidant PD (30%) are associated. Research has consistently linked anorexia (particularly when the patient does not also have binge/purge symptoms) to personality traits such as introversion, conformity, perfectionism and obsessive-compulsive features (Westen and Harnden-Fischer, 2001).

Westen and Harnden-Fischer (2001) conducted a cluster analytic research in eating disordered individuals with both subtypes of anorexia comprising a high functioning/perfectionist group, constricted/over-controlled group and emotionally dysregulated/under-controlled group. The study revealed that all restrictors were rigid and inhibited whereas all bingers were impulsive and novelty seeking. These within–subtype heterogeneities are linked to specific etiological pathways. For paradigm, individuals characterized by dysregulated and under-controlled behavioural patterns might binge due to poor impulse regulation (represents those with cluster B personality disorders), while those categorised as inhibited or over-controlled might binge after an episode of restrictive dieting (refers to those with cluster C personality disorders) (Bruce and Steiger, 2005).

The restricting type anorexic patients possess the characteristic profile as being more obsessive-compulsive, tolerant, perfectionist, introverted and emotionally inhibited whereas the binge-eating/purging type anorexic patients are observed to be more impulsive, depressive, socially dysfunctional, sexually adventurous and substance abusing, with high levels of emotional distress (Garner, 1993; Sansone and Sansone, 2011). The obsessive compulsive personality disorder is often observed in restricting anorexia nervosa whereas borderline personality disorders occur in binge eating/purging type anorexic patients. The most recurrent personality disorder among anorexic patients with restricting type is obsessive-compulsive disorder (22%), followed by avoidant personality disorder (19%). Approximately 10% suffer from borderline or dependant personality disorder and 5% reveal characteristics of the Cluster A PDs. On the whole, Cluster C type personality disorders (paranoid, schizoid, schizotypal) are much dominant in these individuals. In binge-eating/purging type anorexia nervosa, borderline personality disorder was observed to be the most prevalent because of higher levels of impulsivity. From clinical perspective, along with eating pathology a range of other self regulatory difficulties such as substance abuse or other addictions, promiscuity, difficulty managing finances etc. occur which also indicate self-harm behaviour (Sansone *et al.,* 2005).

According to Kuek *et al.* (2015) anorexic individuals are generally observed to have a depressive profile. In a research done by Westen and Harnden (2001) it was observed that patients with prominent anorexic symptoms are likely to fit in a constricted/over-controlled profile i.e. a pattern of constriction and restriction of pleas-

ure, needs, emotions, relationships, self-knowledge, self-reflection, sexuality and depth of understanding of others which is also noticed in the domain of foods habits. They tend to feel empty inside, inadequate, ashamed and are chronically dysphoric/depressed. Their personality pathology tends to be avoidant or schizoid. It is observed that the more the patient matches this personality profile, the lower the level of adaptive functioning tends to be. In some cases, this personality constellation in anorexic individuals reflects a part of categorical adaptation (repetition suppression) to a history of sexual abuse.

Many researchers revealed that anorexic individuals were engaged in binge eating score high on persistence (Fassino *et al.,* 2002). High persistence characterizes industriousness, perseverance, perfectionism, rigidity, and obsessiveness, which might promote restrictive eating behaviour and safeguard against binging and purging. Anorexic patients, specifically the restrictive type, score low on novelty seeking (Fassino *et al.,* 2001; Klump *et al.,* 2000, indicating avoidance of risks and reluctance to engage in new activities. Jappe *et al.* (2011) proposed anorexic patients exhibit the core characteristic of sensitivity to praise and reward and carry on previously rewarded activities till the time of exhaustion. On the aspects of reward dependence, anorexic individuals score similar to bulimic individuals (Fassino *et al.,* 2001). Anorexic individuals are observed to be impulsive, excitable, dramatic and intolerant of routines and these characteristics might contribute to the risk of onset of binge eating, purging or other impulsive behaviours (Boisseau *et al*., 2009). It was also found that anorexic individuals with binging/ purging type tend to score high on novelty seeking (Fassino *et al.* 2001; Fassino *et al.* 2002 and Klump *et al.,* 2000).

Geller *et al.* (2000) research findings suggest that anorexic women had significantly higher scores on anger suppression when compared to controls, reflecting that women with anorexia nervosa are specifically predisposed to inhibit the expression of their thoughts when conflicting with those of others and give priority to the feelings of others over their own. Thus anorexic women spend considerable energy silencing their own thoughts and feelings. Restrained expression for feelings of negativity and interpersonal orientation was also related to pessimistic thoughts and feelings about the body, which consequently leads to body dissatisfaction. Anorexic individuals were unwilling to share difficult and negative thoughts with others, avoiding themselves of the benefits of self disclosure; this group was observed to hold the ideology that confiding in others will consequently lead to a negative outcome.

Anorexic women scrutinize self expression of negative, difficult thoughts/feelings as revealing personal imperfections or character flaws. An inhibited self-expression and outward/external focused inter-personal orientation is significantly observed in anorexic group. Given that perfectionism is a vital feature of anorexic symptomatology (Sutandar-Pinnock *et al.* 2003). Perfectionism is a trait in which an individual has an inborn inclination to set and pursue unrealistically high standards in spite of the prevailing adverse consequences (paradigm, food and weight related anxiety, persistent hunger) (Shafran *et al*., 2002). It is observed that eating disordered patients exhibit neurotic perfectionism to a greater extent (paradigm, over concern with mistakes, anxiety about performance) and similar levels of normal perfectionism (paradigm, high personal standards, need for order) (Sassroli *et al.,* 2008). The Multidimensional Perfectionism Scale evaluates three domains of perfectionism, i.e. self-oriented, other-oriented and socially prescribed perfectionism (Hewitt & Flett, 1991, 2004). Fornieles-Castro *et al.* (2007) suggested that self-oriented and socially prescribed perfectionism is mostly observed in anorexic patients. In another research study conducted by Halmi *et al.* (2000) anorexic patients were observed to have higher scores on the Multidimensional Perfectionism Scale as compared to the controls. Thus the data signified that perfectionism is a strong and discriminating characteristic of anorexic patients. Perfectionism is likely to be one of the clusters of phenotypic trait variables associated with a genetic diathesis for anorexia nervosa. Many researchers suggest that multi-dimensional perfectionism might possibly predict the onset of anorexic symptoms (Tyrka *et al.,* 2002).

According to Davies *et al.* (2009), Perfectionism and obsessive-compulsiveness traits are overlapping and strongly associated with each other (for instance, doubts about actions, rigidity, and concern over mistakes). The characteristics of rigidity, need for control, obsessiveness, pessimism, fear of uncertainty, low impulsivity, orderliness, avoidance of novel situations and reluctance to change are highly associated with anorexic individuals and also correspond to obsessive temperaments (Fassino *et al.,* 2002 and Svrakic *et al.,* 1993). Many personality traits of anorexic individuals are common to various features of perfectionism. Pearson *et al.* (2006) also mentioned the characteristics of anorexic individuals coincide with various facets of perfectionism. The necessity to always appear perfect is similar to harm avoidance. For instance perfectionists avoid criticism by others and are reward dependant in the sense of relying on the approval of others. Low novelty seeking is seen in perfectionist's restraint to indulge in activities that do not guarantee success. High constraint, persistence and low novelty seeking have always been basic attributes of anorexic individuals (Cassin and Ranson, 2005). A cluster analytic study of eating disordered individuals indicates that there is considerable personality variability within ED diagnostic

categories. For instance, a cluster analysis of MMPI responses identified three distinct AN subgroups (Strober, 1980). The first subgroup wanted to conform and exercise control but maintained a sense of well-being and self-acceptance. The second subgroup exhibited a more neurotic personality structure with high levels of anxiety, self-doubt and social inhibitions. The third subgroup revealed impulsivity and low ego strength.

Numerous researches have demonstrated that anorexic individuals are in trouble identifying negative emotions from the face and also those expressed verbally (Kucharska-Pietura *et al.,* 2004). Taylor (1994) and Goerlich (2018) described the term alexithymia as difficulty in recognizing and interpreting emotional states. It also exhibits deficits in processing one's own emotions. Alexithymia might be related to depressive symptoms rather than the eating pathology but it could be a state or a trait in behaviour pattern (Eizaguirre *et al.,* 2004). Anorexic individuals often exhibit extreme characteristics of emotional deficits and inhibition in regard to anxiousness, social avoidance and liability (Holliday *et al.,* 2006). According to Harrison *et al.* (2009) anorexic individuals have reduced emotional awareness. These individuals also prefer social isolation sometimes due to their incompetence in recognising and interpreting social situations. The difficulty in understanding and recognising the emotional states of other fellow individuals and are prone to have impaired interpersonal functions as well as maladaptive personality traits. This emotional dysregulation is known to arise due to various psychological pathologies such as trauma induced anxiety (Rusch *et al.,* 2011), depression (Anderson *et al.,* 2011) and mania (Carolan and Power, 2011). This lack of emotion processing observed in AN generally follows an inhomogeneous pattern, for paradigm, some researchers suggest that the trait anxiety and anxiety sensitivity (Aharoni and Hertz, 2011; Davey,and Chapman, 2009) are exhibited in anorexic patients with an augmented sense of disgust and also due to increased fear and anger (Fox *et al.,* 2003). Absence of empathy in such patients might also occur (Kucharska-Pietura *et al.,* 2004; Pollatos *et al.,* 2008).

Phillips *et al.* (2003) revealed two major neuro-circuits which contribute to the understanding of anorexic behaviour through neuro-physiological imaging studies. To understand the emotional influence of the stimuli and for creating an apt response the ventral (limbic) neuro-circuit which accommodates the insula, amygdala, ventral striatum and ventral parts of the anterior cingulate cortex (ACC) and the orbitofrontal cortex (OFC) are of great significance. The dorsal (cognitive) neuro-circuit includes hippocampus, dorsal regions of ACC, dorsolateral prefrontal cortex (DIPFC), parietal cortex, and other parts that regulate planning, specific attention and control of other affective responses. Several studies have reported that a disturbance in these two neuro-circuits is a risk factor for developing various psychiatric disorders such as depression, anxiety and obsessive-compulsive disorder (OCD). Anxiety disorders are predictive risk factors for the development of eating disorders and have been observed to exist in families afflicted with eating pathology. However, the neurobiological alterations and abnormalities observed in individuals with eating disorders might be different from those found in individuals with anxiety, depression and OCD. For instance, the adhering capacity of serotonin (5-HT) receptor 1A (5-HT_{1A}) is reduced in panic disorders (Neumeister *et al.,* 2004), social phobias (Lanzenberger *et al.,* 2007) and depression (Drevets *et al.,* 2007), but it increases in individuals with eating disorders (Tiihonen *et al.,* 2004; Bailer *et al.,* 2007; Galusca *et al.,* 2008). Evidence suggests that aggressive and impulsive behaviour patterns are dependent upon an increase or decrease of 5-HT activity (Schweighofer *et al,* 2007; Westergaard *et al.,* 2003).

Interestingly, an altered functioning in the frontal, parietal and cingulate regions continues even after recovery from AN (Rastam *et al.,* 2003; Uher *et al.,* 2001). Though the abnormal functioning of these neural circuits causes altered emotions and obsessive behaviour, the molecular basis of these deregulations varies with regard to the different forms of eating disorders (Phillips *et al.,* 2003). In a study conducted on recovered anorexics, positive associations in the 5-HT transporter system and D2/D3 receptor binding in the dorsal caudate and ventral striatum were also demonstrated, indicating harm avoidance behaviour pattern which was observed in the dorsal caudate region of the brain (Kaye *et al.,* 2009). Increased stress is majorly linked to the brain's serotonin system involved in AN pathology (Kaye *et al.,* 2009). According to this, anorexic individuals indulge in frequent habitual self-starvation to decrease dysphoric mood and stress through the serotonergic pathway which is involved in fear, depression, anxiety, satiety and obsessive-compulsive behaviours (Kaye *et al.,* 2009). Self-starvation is a reward based which is related to the dopaminergic pathway (Zink and Weinberger, 2010; Fladung *et al.,* 2010). Fladung *et al.* (2010) conducted an fMRI study, which included 14 anorexic females and 14 healthy female controls. The participants were shown images of females who were either underweight, normal weight or overweight and were asked to perceive their personal viewpoints and feelings with an assumption of acquiring the same body weight. The revelations were that anorexic females had an augmented activity in their ventral striatum region of the brain as part of the reward system; however, the healthy controls favoured images of normal weight females. Thus, the study implies that such behaviours arise from profound pathology that might be rooted in the individual's early development. Several studies

have associated the serotonergic pathways with the development of fear, anxiety and depression in anorexic individuals, however, despite weight stabilization the anorexic psychopathology persists. The continuance of this psychopathology despite weight improvement specifies further reinforcement is still essential. However, according to Frank *et al.* (2005) and Kaye *et al.* (1999), a drug named olanzapine might lead to weight gain through its effects on DA and 5-HT systems and it might also be helpful in reducing anxiety (Bergen *et al.,* 2005) in individuals with AN but it is still under speculation. In addition, other antipsychotics might also prove beneficial (Kaye *et al.,* 2009).

Conclusion

Eating disorders are significantly heritable, causing altered brain activity and, in certain cases, impaired cognitive function, decisions, and emotional stability. Anorexia nervosa and its further variants are considered genetic in origin, psychological illnesses that require the equal extent of healthcare approach as for similar conditions such as depression, anxiety, obsessive-compulsive disorder etc. A perspective approach to recognize and scientifically map the distorted personality traits and pathologies pertaining to specific eating disorders need to be established. However, significant limitations still prevail in the neurotransmitter studies done in humans, i.e. only a narrow range of neuro-modulatory components can be examined. The complex interactions within the biochemical mechanisms are still largely unknown. The medical treatments or related cures available have not totally proven to eliminate the core symptomatology of anorexia nervosa. Extensive research is required to identify the drugs which might help stabilize the altered neurobiological processes and related appetitive pathways. Moreover, intervention in terms of cognitive therapies and therapeutic counselling focused on the all-inclusive range of anorexic symptoms during initial identification of the disorder and even in recovered anorexics is indispensable.

Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

1. Aharoni, R., & Hertz, M. M. (2011). Disgust sensitivity and anorexia nervosa. *Eur. Eat. Disord. Rev.,* 20(2), 106–110. Doi:10.1002/erv.1124
2. APA (1994) Diagnostic and statistical manual of mental disorders (DSM-4). American Psychiatric Association (APA), Washington, DC: Author.
3. APA (2013) *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5). American Psychiatric Association (APA), Washington, DC: Author.
4. Anderluh, M.B., Tchanturia, K., Rabe-Hesketh, S. & Treasure, J. (2003). Childhood obsessive-compulsive personality traits in adult women with eating disorders: defining a broader eating disorder phenotype. *Am. J. Psychiatry*, 160(2), 242–47. Doi:10.1176/appi.ajp.160.2.242
5. Anderson, I. M., Shippen, C., Juhasz, G., Chase, D., Thomas, E., Downey, D., Toth, Z. G., Lloyd-Williams, K., Elliott, R., Deakin, J. F. (2011). State-dependent alteration in face emotion recognition in depression. *Br. J. Psychiatry*, 198(4), 302–308. Doi: 10.1192/bjp.bp.110.078139
6. Attia, E., Wolk, S., Cooper, T., Glasofer, D. & Walsh, B. (2005). Plasma tryptophan during weight restoration in patients with anorexia nervosa. *Biol Psychiatry*, 57, 674–678. Doi: 10.1016/j.biopsych.2004.11.045
7. Audenaert, K., Laere, K. V., Dumont, F., Vervaet, M., Goethals, I., Sleger, G., Mertens, J., Heeringen, C. V. & Dierckx, R. A. (2003). Decreased 5-HT2a receptor binding in patients with anorexia nervosa. *J. Nucl.Med*, 44(2), 163–169. PMID: 12571204
8. Kaye, W. H., Bailer, U. F., Frank, G. K., Henry, S. E., Price, J. C., Meltzer, C. C., Becker, C., Ziolko, S. K., Mathis, C. A., Wagner, A., Barbarich-Marsteller, N. C., & Putnam, K. (2007). Serotonin transporter binding after recovery from eating disorders. *Psychopharmacology,* 197 (3), 521–2. Doi: 10.1007/s00213-007-1048-9
9. Bailer, U. F., Frank, G. K., Henry, S. E., Price, J. C., Meltzer, C. C., Mathis, C. A., Wagner, A., Thornton, L., Hoge, J., Ziolko, S. K., Becker, C. R., McConaha, C. W. & Kaye, W. (2007)Exaggerated 5-HT1A but normal 5-HT2A receptor activity in individuals ill with anorexia nervosa. *Biol. Psychiatry*, 61(9), 1090–1099. Doi:10.1016/j.biopsych.2006.07.018
10. Bailer, U. F., Frank, G. K., Henry, S. E., Price, J. C., Meltzer, C. C., Weissfeld, L., Mathis, C. A., Drevets, W. C., Wagner, A., Hoge, J., Ziolko, S. K., McConaha, C. W. & Kaye, W. (2005). Altered brain serotonin 5-HT1 receptor binding after recovery from anorexia nervosa measured by positron emission tomography and [Carbonyl11C] WAY -100635. *Arch Gen Psychiatry*, 62(9), 1032–1041. Doi: 10.1001/archpsyc.62.9.1032.
11. Bari, A., Theobald, D. E., Caprioli, D., Mar, A. C., Aidoo-Micah, A., Dalley, J. W. & Robbins, T. W. (2010). Serotonin modulates sensitivity to reward and negative feedback in a probabilistic reversal learning task in rats. *Neuropsychopharmacology*, 35(6), 1290–1301. Doi: 10.1038/npp.2009.233
12. Bergen, A., Yeager, M., Welch, R. A., Haque, K., Ganjei, J. K., Van den Bree, M. B., Mazzanti, C., Nardi, I., Fichter, M. M., Halmi, K. A., Kaplan, A. S., Strober, M., Treasure, J., Woodside, D. B., Bulik, C. M., Bacanu, S. A., Devlin, B., Berrettini, W. H., Goldman, D. & Kaye, W. (2005).Association of multiple DRD2 polymorphisms with anorexia nervosa. *Neuropsychopharmacology*, 30(9), 1703–1710. Doi: 10.1038/sj.npp.1300719
13. Bergen, A. W., Bree, V., Yeager, M., Welch, R., Ganjei, K., Haque, J. K., et al. (2003). Candidate genes for anorexia nervosa in the 1p33-36 linkage region: Serotonin 1D and delta opioid receptor loci display significant association to anorexia nervosa. *Mol Psychiatry*, 8(4), 397–406.Doi: 10.1038/sj.mp.4001318
14. Bornstein, R. F. (2001). A meta-analysis of the dependen-

cy–eating-disorders relationship: Strength, specificity, and temporal stability. *J. Psychopathol. Behav. Assess*, 23(3), 151–162.Doi:10.1023/A:1010913203679
15. Boisseau, C., Thompson-Brenner, H., Eddy, K., Satir, D. (2009). Impulsivity and Personality Variables in Adolescents with Eating Disorders. *J. Nerv. Ment. Dis.*, 197(4), 251-59. Doi: 10.1097/NMD.0b013e31819d96c0
16. Bruce, K. R. & Steiger, H. (2005). Treatment implications of Axis-II comorbidity in eating disorders. *J Eat Disord*, 13 (1), 93–108. Doi: 10.1080/10640260590893700
17. Calandra, C., Musso, F., & Musso, R. (2003). The role of leptin in the etiopathogenesis of anorexia nervosa and bulimia. *Eat. Weight Disord.*, 8(2), 130-7. Doi: 10.1007/BF03325002.
18. Carli, M., Baviera, M., Invernizzi, R. & Balducci, C. (2006). Dissociable contribution of 5-HT1A and 5-HT2A receptors in the medial prefrontal cortex to different aspects of executive control such as impulsivity and compulsive perseveration in rats. *Neuropsychopharmacology*, 31(4), 757–767. Doi: 10.1038/sj.npp.1300893
19. Carolan, L. A., Power, M. J. (2011). What basic emotions are experienced in bipolar disorder? *Clin Psychol Psychother*, 18(5), 366–378. Doi:10.1002/cpp.777
20. Cassin, S. & Ranson, K. (2005). Personality and eating disorders: A decade in review. *Clin Psychol Rev*, 25(7), 895–916. Doi: 10.1016/j.cpr.2005.04.012
21. Cools, R., Roberts, A. & Robbins, T. (2008). Serotoninergic regulation of emotional and behavioural control processes. *Trends Cogn Sci*, 12(1), 31–40. Doi: 10.1016/j.tics.2007.10.011.
22. Coplan, J.D., Fathy, H.M., Jackowski, A.P., Tang, C.Y., Perera, T.D., et al., (2014). Early life stress and macaque amygdala hypertrophy: preliminary evidence for a role for the serotonin transporter gene. Front Behav Neurosci 8, 342. Doi: 10.3389/fnbeh.2014.00342
23. Davey, G. C., Chapman, L. (2009). Disgust and eating disorder symptomatology in a non-clinical population: the role of trait anxiety anxiety sensitivity. *Clin Psychol Psychother*, 16(4), 268–275. Doi: 10.1002/cpp.623
24. Davies, H., Liao, C., Campbell, I..& Tchanturia, K. (2009). Multidimensional self reports as a measure of characteristics in people with eating disorders. *Eat Weight Disord*, 14, e84–e91. Doi: 10.1007/BF03327804
25. Daw, N. D., Kakade, S. & Dayan, P. (2002). Opponent interactions between serotonin and dopamine. *NeuralNetworks*, 15(4-6), 603–616. Doi: 10.1016/S0893-6080(02)00052-7
26. Di Matteo, V., Di Giovanni, G., Di Mascio, M. & Esposito, E. (2000). Biochemical and electrophysiological evidence that RO 60–0175 inhibits mesolimbic dopaminergic function through serotonin2C receptors. *Brain Res*, 865(1), 85–90. Doi: 10.1016/s0006-8993(00)02246-0
27. Eizaguirre, A. E., Saenz de Cabezon, A. O., Alda, I. O., Olariaga, L. J. & Juaniz, M. (2004). Alexithymia and its relationships with anxiety and depression in eating disorders. *Pers Individ Differ*, 36(2), 321–331. Doi:10.1016/S0191-8869(03)00099-0
28. Fairbanks, L., Melega, W., Jorgensen, M., Kaplan, J. & McGuire, M. (2001). Social impulsivity inversely associated with CSF 5-HIAA and fluoxetine exposure in vermet monkeys. *Neuropsychopharmacology*, 24(4), 370–378. Doi:10.1016/S0893-133X(00)00211-6
29. Fassino, S., Abbate-Daga, G., Amianto, F., Leombruni, P., Boggio, S. & Rovera, G. G. (2002). Temperament and character profile of eating disorders: a controlled study with the Temperament and Character Inventory. *Int J Eat Disord*, 32(4), 412–425. Doi:10.1002/eat.10099
30. Fassino, S., Daga, G. A., Piero, A., Leombruni, P. & Rovera, G. G. (2001). Anger and personality in eating disorders. *J. Psychosom. Res.*, 51(6), 757–764. Doi:10.1016/s0022-3999(01)00280-x
31. File, S. E., Kenny, P. J. & Cheeta, S. (2000). The role of the dorsal hippocampal serotonergic and cholinergic systems in the modulation of anxiety. *Pharmacol. Biochem. Behav*, 66(1), 65–72. Doi:10.1016/s0091-3057(00)00198-2.
32. Fladung, A. K., Gron, G., Grammer, K., Herrnberger, B., Schilly, E., Grasteit, S., Wolf, R. C., Walter, H. & Von Wietersheim, J. (2010). Neural signature of anorexia nervosa in the ventral striatal reward system. *Am. J. Psychiatry*, 167(2), 206–212. Doi:10.1176/appi.ajp.2009.09010071
33. Fornieles-Castro, J., Gual, P., Lahortiga, F., Gila, A., Casula, V., Fuhrmann, C., Imirizaldu, M., Saura, B., Martinez, E. & Toro, J. (2007). Self-oriented perfectionism in eating disorders. *Int. J. Eat. Disord*, 40(6), 562-8. Doi: 10.1002/eat.20393
34. Fox, J. R., Smithson, E., Baillie, S., Ferreira, N., Mayr, I., & Power, M. J. (2013). Emotion coupling and regulation in anorexia nervosa. *Clin. Psychol. Psychother*, 20(4), 319–333. Doi:10.1002/cpp.1823
35. Frank, G., Bailer, U. F., Henry, S. E., Drevets, W., Meltzer, C. C., Price, J. C., Mathis, C. A., Wagner, A., Hoge, J., Ziolko, S., Barbarich-Marsteller, N., Weissfeld, L. & Kaye, W. (2005).Increased dopamine D2/D3 receptor binding after recovery from anorexia nervosa measured by positron emission tomography and [11C] raclopride. *Biol. Psychiatry*, 58(11), 908–912. Doi:10.1016/j.biopsych.2005.05.003.
36. Frank, G., Kaye, W. H., Meltzer, C. C., Price, J. C., Greer, P., McConaha, C. & Skovira, K. (2002).Reduced 5-HT2A receptor binding after recovery from anorexia nervosa. *Biol Psychiatry*, 52(9), 896–906. Doi:10.1016/s0006-3223(02)01378-1
37. Frank, G. K., Kaye, W. H., Weltzin, T. E., Perel, J., Moss, H., McConaha, C. & Pollice, C. (2001). Altered response to metachlorophenylpiperazinein anorexia nervosa: support for a persistent alteration of serotonin activity after short-term weight restoration. *Int J Eat Disord*, 30(1), 57–68. Doi:10.1002/eat.1054
38. Galusca, B., Costes, N., Zito, N. G., Peyron, R., Bossu, C., Lang, F., Le Bars, D. & Estour, B. (2008). Organic background of restrictive type anorexia nervosa suggested by increased serotonin1A receptor binding in right frontotemporal cortex of both lean and recovered patients: [18F] MPPF PET scan study. *Biol Psychiatry*, 64(11), 1009–1013. Doi:10.1016/j.biopsych.2008.06.006
39. Garner, D. M. (1993). Pathogenesis of anorexia nervosa. *The Lancet*, 341(8861), 1631-35. Doi:10.1016/0140-6736(93)90768-c
40. Geller, J., Cockell, S. J. & Goldner, E. M. (2000). Inhibited expression of negative emotions and interpersonal orientation in anorexia nervosa. *Int J Eat Disord*, 28(1), 8–19. Doi:10.1002/1098-108x(200007)28:1<8::aid-eat2>3.0.co;2

-u
41. Godart, N., Perdereau,F. Z., Berthoz, R. S.,Wallier, J., Flament, M. F. (2007). Comorbidity studies of eating disorders and mood disorders. Critical review of the literature. *J Affect Disord*, 97(1-3), 37–49.Doi:10.1016/j.jad.2006.06.023
42. Goerlich, K. (2018). The multifaceted nature of alexithymia – A neuroscientific perspective. *Front Psychol*, 9, 1614. Doi: 10.3389/fpsyg.2018.01614
43. Grice, D. E., Halmi, K. A., Fichter, M. M., Treasure, J. T., Kaplan, A. S., Magistretti, P. J., et al. (2002). Evidence for a susceptibility gene for anorexia nervosa on chromosome 1. *Am J Hum Genet*, 70(3), 787–792. Doi:10.1086/339250
44. Halford, J. C., Cooper, G. D. & Dovey, T. M. (2004). The pharmacology of human appetite expression. *Curr Drug Targets*, 5(3), 221–40. Doi:10.2174/1389450043490541
45. Halmi, K., Agras, W. S., Crow, S., Mitchell, J., Wilson, G. T., Bryson, S. W. & Kraemer, H. C. (2005). Predictors of treatment acceptance and completion in anorexia nervosa. *Arch Gen Psychiatry*, 62(7), 776–781. Doi:10.1001/archpsyc.62.7.776.
46. Halmi, K. A., Sunday, S. R., Strober, M., Kaplan, A., Woodside, D. B., Fichter, M., Treasure, J., Berrettini, & Kaye, W. H. (2000). Perfectionism in Anorexia Nervosa-Variation by Clinical Subtype, Obsessionality, and Pathological Eating Behavior. *Am. J. Psychiatry*, 157(11), 1799-1805. Doi:10.1176/appi.ajp.157.11.1799
47. Harrison, A., Sullivan, S., Tchanturia, K. & Treasure, J. (2009). Emotion Recognition and Regulation in Anorexia Nervosa. *Clin Psychol Psychother*, 16(4), 348–356. Doi:10.1002/cpp.628.
48. Hashimoto, K., Koizumi, H., Nakazato, M., Shimizu, E. & Iyo, M. (2005). Role of brain-derived neurotrophic factor in eating disorders: Recent findings and its pathophysiological implications. *Prog. Neuropsychopharmacol Biol. Psychiatry*, 29(4), 499–504. Doi:10.1016/j.pnpbp.2005.01.007
49. Hewitt, P. L. & Flett, G. L. (1991). Perfectionism in the self and social contexts: Conceptualization, assessment, and association with psychopathology. *J. Pers. Soc. Psychol.*, 60(3), 456–470. Doi:10.1037//0022-3514.60.3.456
50. Hewitt, P. L., & Flett, G. L. (2004). Multidimensional Perfectionism Scale (MPS): Technical manual. Toronto, Canada: Multi-Health Systems.
51. Hoek, W. (2006). Incidence, prevalence and mortality of anorexia nervosa and other eating disorders. *Curr Opin Psychiatry*, 19(4), 389–394. Doi:10.1097/01.yco.0000228759.95237.78.
52. Holliday, J., Uher, R., Landau, S., Collier, D. & Treasure, J. (2006) Personality pathology among individuals with a lifetime history of anorexia nervosa. *J. Pers. Disord.*, 20(4), 417–430. Doi:10.1521/pedi.2006.20.4.417.
53. Hudson, J., Hiripi, E., Pope, H. G. & Kessler, R. C. (2007). The prevalence and correlates of eating disorders in the national comorbidity survey replication. *Biol. Psychiatry*, 61 (3), 348–58. Doi:10.1016/j.biopsych.2006.03.040.
54. Inui, A. (2001). Eating behavior in anorexia nervosa—an excess of both orexigenic and anorexigenic signalling? *Mol. Psychiatry*, 6(6), 620–624. Doi:10.1038/sj.mp.4000944.
55. Jacobi, C., Hayward, C., Zwaan, M., Kraemer, H. C. & Agras, W. S. (2004). Coming to terms with risk factors for eating disorders: application of risk terminology and suggestions for a general taxonomy. *Psychol. Bull.*, 130(1), 19–65. Doi: 10.1037/0033-2909.130.1.19.
56. Jappe, L., Frank, G., Shott, M., Rollin, M., Pryor, T., Hagman, J., Yang, T. & Davis, E. (2011). Heightened sensitivity to reward and punishment in anorexia nervosa. *Int. J. Eat. Disord.*, 44(4), 317-24. Doi: 10.1002/eat.20815
57. Jiang, X., Xu, K., Hoberman, J., Tian, F., Marko, A., Waheed, J., Harris, ., Marini, A., Enoch, M., Lipsky, R. (2005). BDNF variation and mooddisorders: A novel functional promoter polymorphism and val66Met are associated with anxiety but have opposing effects. *Neuropsychopharmacol*, 30, 1353–1361. Doi: 10.1038/sj.npp.1300703
58. Jimerson, D., Wolfe, B. (2006). Psychobiology of eating disorders in *Annual Review of Eating Disorders, Part 2* (eds Wonderlich, S., Mitchell, J., De Zwann, M. & Steiger, H.) 1–15 (Radcliffe Publishing Ltd, Abingdon UK).
59. Johnson, C. & Wonderlich, S. A. (1992). Personality characteristics as a risk factor in the development of eating disorders. In J. H. Crowther, & D. L. Tennenbaum (Eds.), The etiology of bulimia nervosa: The individual and familial context (pp. 179–196). Kent, OH7 Kent State University Press.
60. Kaye, W. (2007). Neurobiology of anorexia and bulimia nervosa. *Physiol. Behav.*, 94(1), 121-35. Doi:10.1016/j.physbeh.2007.11.037.
61. Kaye, W., Barbarich, N. C., Putnam, K., Gendall, K. A., Fernstrom, J., Fernstorm, M., McConaha & Kishore, A. (2003). Anxiolytic effects of acute tryptophan depletion in anorexia nervosa. *Int. J. Eat. Disord*, 33(3), 257–267. Doi:10.1002/eat.10135
62. Kaye, W., Bulik, C. M., Thornton, L., Barbarich, N., Masters, K. (2004). Comorbidity of anxiety disorders with anorexia bulimia nervosa. *Am. J. Psychiatry*, 161 (12), 2215–2221. Doi: 10.1176/appi.ajp.161.12.2215
63. Kaye, W., Frank, G., Bailer, U. F. & Henry, S. (2005). Neurobiology of anorexia nervosa: clinical implications of alterations of the function of serotonin and other neuronal systems. *Int. J. Eat. Disord.*, 37, S15–S19. Doi:10.1002/eat.20109
64. Kaye, W., Frank, G. K. & McConaha, C. (1999). Altered dopamine activity after recovery from restricting-type anorexia nervosa. *Neuropsychopharmacology*, 21(4), 503–506. Doi:10.1016/S0893-133X(99)00053-6
65. Kaye, W., Gwirtsman, H. E., George, D. T. & Ebert, M. H. (1991). Altered serotonin activity in anorexia nervosa after long-term weight restoration. Does elevated cerebrospinal fluid 5-hydroxyindoleacetic acid level correlate with rigid and obsessive behavior? *Arch. Gen. Psychiatry*, 48(6), 556–562. Doi:10.1001/archpsyc.1991.01810300068010.
66. Kaye, W., Gwirtsman, H. E., George, D. T., Jimerson, D. C. & Ebert, M. H. (1988). CSF 5-HIAA concentrations in anorexia nervosa: reduced values in underweight subjects normalize after weight gain. *Biol. Psychiatry*, 23(1), 102–105. Doi:10.1016/0006-3223(88)90113-8
67. Kaye, W., Wagner, A., Frank, G. (2006). Review of brain imaging in anorexia and bulimia nervosa in *Annual Review of Eating Disorders, Part 2* (eds Wonderlich, S., Mitchell, J., De Zwann, M. & Steiger, H.) 113–130 (Radcliffe Publishing Ltd, Abingdon UK).
68. Kaye, W. H., Frank, G. K., Bailer, U. F., Henry, S. E.,

Meltzer, C. C., Price, J. D., et al. (2005). Serotonin alterations in anorexia and bulimia nervosa: New insights from imaging studies. *Physiol. Behav.*, 85(1), 73–81. Doi:10.1016/j.physbeh.2005.04.013

69. Kaye, W. H., Frank, G. K., Meltzer, C. C., Price, J. C., McConaha, C., Crossan, P. J., et al. (2001). Altered serotonin 2A receptor activity after recovery from bulimia nervosa. *Am. J. Psychiatry*, 158(7), 1152–1155. Doi:10.1176/appi.ajp.158.7.1152
70. Kaye, W. H., Fudge, J. L., Paulus, M. (2009). New insights into symptoms and neurocircuit function of anorexia nervosa. *Nat. Rev. Neurosci.*, 10(8), 573-584. Doi:10.1038/nrn2682
71. Kaye, W. H., Gwirtsman, H. E., George, D. T., Ebert, M. H., Jimerson, D. C., Tomai, T. P., Chrousos, G. P., Gold, P. W. (1987). Elevated cerebrospinal fluid levels of immunoreactive corticotropin-releasing hormone in anorexia nervosa: relation to state of nutrition, adrenal function, and intensity of depression. *J. Clin. Endocrinol. Metab.*, 64(2), 203–208. Doi:10.1210/jcem-64-2-203
72. Kaye, W. H., Strober, M. & Klump, K. L., editors (2002) Serotonin Neuronal Function in Anorexia and Bulimia Nervosa. Washington, DC: American Psychiatric Publishing.
73. Klump, K., Strober, M., Bulik, C. M., Thornton, L., Johnson, C., Devlin, B., Fichter, M. M., Halmi, K. A., Kaplan, A. S., Woodside, D. B., Crow, S., Mitchell, J., Rotondo, A., Keel, P. K., Berrettini, W. H., Plotnicov, K., Pollice, C., Lilenfeld, L. R. and Kaye, W. H. (2004) Personality characteristics of women before and after recovery from an eating disorder. *Psych. Med.*, 34(8), 1407–1418. Doi:10.1017/s0033291704002442.
74. Klump, K. L., Bulik, C. M., Pollice, C., Halmi, K. A., Fichter, M. M., Berrettini, W. H. et al. (2000). Temperament and character in women with anorexia nervosa. *J. Nerv. Ment. Dis.*, 188(9), 559–567. Doi:10.1097/00005053-200009000-00001
75. Klump, K. L., Culbert, K. M. (2007). Molecular genetic studies of eating disorders: Current status and future directions. *Curr. Dir. Psychol. Sci.*, 16(1), 37–41. Doi:10.1111/j.1467-8721.2007.00471.x
76. Klump, K. L., McGue, M. & Iacono, W. G. (2003). Differential heritability of eating pathology in pre-pubertal versus pubertal twins. *Int. J. Eat. Disord.*, 33(3), 287–292. Doi:10.1002/eat.10151.
77. Kucharska-Pietura, K., Nikolaou, V., Masiak, M. & Treasure, J. (2004). The recognition of emotion in the faces and voice of anorexia nervosa. *Int. J. Eat. Disord.*, 35(1), 42–47. Doi:10.1002/eat.10219
78. Kuek, A., Utpala, R. & Lee, H. (2015). The clinical profile of patients with anorexia nervosa in Singapore: a follow-up descriptive study. *Singapore Med. J.*, 56(6), 324-328. Doi: 10.11622/smedj.2015090
79. Lesch, K., Merschdorf, U. (2000). Impulsivity, aggression, and serotonin: a molecular psychobiological perspective. *Behav. Sci. Law*, 185(5), 581–604. Doi:10.1002/1099-0798(200010)18:5<581::aid-bsl411>3.0.co;2-l
80. Lopez, C., Tchanturia, K., Stahl, D., Booth, R., Holliday, J. & Treasure, J. (2008).An examination of the concept of central coherence in women with anorexia nervosa. *Int J Eat Disord*, 41(2), 143–152. Doi:10.1002/eat.20478
81. McClure, S., Laibson, D., Loewenstein, G. & Cohen, J. (2004) Separate neural systems value immediate and delayed monetary rewards. *Science*, 306(5695), 503–507. Doi:10.1126/science.1100907
82. Montague, R., Hyman, S. & Cohen, J. (2004). Computational roles for dopamine in behavioural control. *Nature*, 431(7010), 760–767. Doi:10.1038/nature03015.
83. Moresco, F. M., Dieci, M., Vita, A., Messa, C., Gobbo, C., Galli, L., Rizzo, G., Panzacchi, A., De Peri, L., Invernizzi, G. and Fazio, F. (2002). *In vivo* serotonin 5HT2A receptor binding and personality traits in healthy subjects: A positron emission tomography study. *NeuroImage*, 17(3), 1470–1478. Doi:10.1006/nimg.2002.1239
84. Mustelin, L., Yasmina, S., Raevuori, A., Hans, H., Kaprio, J. and Keski-Rahkonen, A. (2016). The DSM-5 diagnostic criteria for anorexia nervosa may change its population prevalence and prognostic value. *J Psychiatr Res*, 77, 85-91. Doi: 10.1016/j.jpsychires.2016.03.003
85. Neumeister, A., Bain, E., Nugent, A. C., Carson, R. E., Bonne, O., Luckenbaugh, D. A., Eckelman, W., Herscovitch, P., Charney, D. S. and Drevets, W. C. (2004). Reduced serotinin type 1A receptor binding in panic disorder. *J Neurosci*, 24(3), 589–591. Doi:10.1523/JNEUROSCI.4921-03.2004
86. Norton, N. and Owen, M. J. (2005). 5HTR2A Association and expression studies in neuropsychiatric genetics. Ann Med, 37(2), 121–129. Doi:10.1080/07853890510037347
87. Pearson, C. and Gleaves, D. (2006). The multiple dimensions of perfectionism and their relation with eating disorder features. *Pers Individ Differ*, 41(2), 225-235. Doi: 10.1016/j.paid.2006.01.013.
88. Phillips, M., Drevets, W. R., Rauch, S. L. and Lane, R. (2003). Neurobiology of emotion perception I: The neural basis of normal emotion perception. *Biol Psych*, 54(5), 504–514. Doi:10.1016/s0006-3223(03)00168-9
89. Pollatos, O., Herbert, B. M., Schandry, R., Gramann, K. (2008). Impaired central processing of emotional faces in anorexia nervosa. *Psychosom Med*, 70(6), 701–708. Doi:10.1097/PSY.0b013e31817e41e6
90. Rastam, M., Bjure, J., Vestergren, E., Uvebrant, P., Gillberg, I. C., Wentz, E., Gillberg, C. (2001). Regional cerebral blood flow in weight-restored anorexia nervosa: a preliminary study. *Dev Med Child Neurol*, 43(4), 239–242. Doi:10.1017/s0012162201000457
91. Ribases, M., Gratacòs, M., Armengol, L. *et al.* (2003). Met66 in the brain-derived neurotrophic factor (BDNF) precursor is associated with anorexia nervosa restrictive type. *Mol Psychiatry* 8, 745–751. Doi: 10.1038/sj.mp.4001281
92. Ribases, M., Gratacos, M., Fernandez-Aranda, F., Bellodi, L., Boni, C., Anderluh, M., et al. (2004). Association of BDNF with anorexia, bulimia and age of onset of weight loss in six European populations. *Hum Mol Genet*, 13(12), 1205–1212. Doi:10.1093/hmg/ddh137
93. Ribases, M., Gratacos, M., Fernandez-Aranda, F., Bellodi, L., Boni, C., Anderluh, M., et al. (2005). Association of BDNF with restricting anorexia nervosa and minimum body mass index: A family-based association study of eight European populations. *Eur J Hum Genet*, 13(4), 428–434. Doi:10.1038/sj.ejhg.5201351.
94. Rikani. A., Choudhry. Z., Choudhry. A., Ikram. H., Asghar. M., *et al.* (2013). A critique of the literature on etiology of eating disorders. *Ann Neurosci*, 20(4), 157-161. Doi:

10.5214/ans.0972.7531.200409
95. Rusch, N., Schulz, D., Valerius, G., Steil, R., Bohus, M., Schmahl, C. (2011). Disgust and implicit self-concept in women with borderline personality disorder and posttraumatic stress disorder. *Eur Arch Psychiatry Clin Neurosci*, 261(5), 369–376. Doi:10.1007/s00406-010-0174-2
96. Sassroli, S., Romero, L., Giovanni, L., Massimo, R., Mauri, C. et. al, (2008). Perfectionism in depression, obsessive -compulsive disorder and eating disorders. *Behav Res Ther*, 46(6), 757-65. Doi: 10.1016/j.brat.2008.02.007
97. Sansone, R. And Sansone, L. (2011) Personality Pathology and Its Influence on Eating Disorders. Innov Clin Neurosci, 8(3), 14-18. Doi: 10.1080/10640260590893593
98. Sansone, R., Levitt, J. and Sansone, L. A. (2005). The Prevalence of Personality Disorders Among Those with Eating Disorders. *J Eat Disord*, 13(1), 7–21. Doi:10.1080/10640260590893593
99. Santana, N., Bortolozzi, A., Serrats, J., Mengod, G. and Artigas, F. (2004). Expression of serotoinin1A and serotonin2A receptor in pyramidal and GABAergic neurons of the rat prefrontal cortex. *Cereb Cortex*, 14(10), 1100–1109. Doi:10.1093/cercor/bhh070
100. Schultz, W. (2004). Neural coding of basic reward terms of animal learning theory, game theory, microeconomics and behavioural ecology. *Science*, 14(2), 139–147. Doi:10.1016/j.conb.2004.03.017
101. Schwartz, M. W., Woods, S. C., Porte, D., Seeley, R. J. and Baskin, D. G. (2000). Central nervous system control of food intake. *Nature*, 404(6778), 661–671. Doi:10.1038/35007534
102. Schweighofer, N., Tanaka, S. and Doya, K. (2007). Serotonin and the evaluation of future rewards: theory, experiments, and possible neural mechanisms. *Ann Ny Acad Sci*, 1104, 289–300. Doi:10.1196/annals.1390.011
103. Shafran, R., Cooper, Z. and Fairburn, C. G. (2002). Clinical perfectionism: A cognitive-behavioural analysis. *Behav Res Ther*, 40(7), 773–791. Doi:10.1016/s0005-7967(01)00059-6
104. Shively, C. A. and Bethea, C. L. (2004). Cognition, mood disorders, and sex hormones.*ILAR J*, 45(2), 189–199. Doi:10.1093/ilar.45.2.189
105. Simansky, K. J., DaveBeth, K., RInemer, D., Nicklous, M., Padron, M., Aloyo, V. and Romano, J. (2004). A 5-HT2C agonist elicits hyperactivity and oral dyskinesia with hypophagia in rabbits. *Physiol Behav*, 82(1), 97–107. Doi:10.1016/j.physbeh.2004.04.028
106. Smink, F. R., Van Hoeken, D. and Hoek, H. W. (2012). Epidemiology of eating disorders: incidence, prevalence and mortality rates. *Curr Psychiatr Rep*, 14(4), 406–14. Doi:10.1007/s11920-012-0282-y.
107. Steiger, H., Richardson, J., Israel, M., Ng Ying Kin, N., Mansou, S. and Parent, A. (2005). Reduced density of platelet binding sites for [3H-] paroxetine in remitted bulimic women. *Neuropsychopharmacology*, 30(5), 1028–1032. Doi:10.1038/sj.npp.1300693
108. Stice, E. (2002). Risk and maintenance factors for eating pathology: a meta-analytic review. *Psychopharm Bull*, 128 (5), 825–848. Doi :10.1037/0033-2909.128.5.825
109. Strober, M. (1980). Personality and symptomatological features in young, nonchronic anorexia nervosa patients. *J Psychosom Res*, 24(6), 353-359. Doi:10.1016/0022-3999(80)90027-6
110. Strober, M. (2005). Family-genetic perspectives on anorexia nervosa and bulimia nervosa. in *Eating Disorders andObesity - A Comprehensive Handbook* (eds. Brownell K & Fairburn C) 212–218 (The Guilford Press, New York).
111. Sutandar-Pinnock, K., Woodside, B., Carter, C., Olmsted, M.,.Kaplan, A., (2003). Perfectionism in anorexia nervosa: A 6–24□month follow□up study. *Int J Eat Disord*, 33(2), 225-229. Doi: 10.1002/eat.10127
112. Svrakic, D. M., Whitehead, C., Przybeck, T. R. and Cloninger, C. R. (1993). Differential diagnosis of personality disorders by the seven factor model of temperament and character. *Arch Gen Psychiatry*, 50(12), 991–999. Doi :10.1001/archpsyc.1993.01820240075009
113. Tauscher, J., Bagby, R. M., Javanmard, M., Christensen, B. K., Kasper, S. and Kapur, S. (2001).Inverse relationship between serotonin 5-HT1A receptor binding and anxiety: a [11C] WAY-100635 PET investigation in healthy volunteers. *Am J Psychiatry*, 158(8),1326–1328. Doi :10.1176/appi.ajp.158.8.1326
114. Taylor, G. J. (1994). The alexithymia construct: Conceptualization,validation and the relationship with basic dimensions of personality. *New Trends in ExperimentalClinical Psychology*, 10(2), 61–74. Corpus ID: 202290673
115. Tierney, A. (2020). Feeding, hunger, satiety and serotonin in invertebrates. *Proc Biol Sci*, 287(1932), 20201386. Doi: 10.1098/rspb.2020.1386
116. Tiihonen, J., Keski-Rahkonen, A., Löppönen, M., Muhonen, M., Kajander, J., Allonen, T., Någren, K., Hietala, J., Rissanen, A. (2004).Brain serotonin 1A receptor binding in bulimia nervosa. *Biol Psychiatry*, 55(8), 871–873. Doi :10.1016/j.biopsych.2003.12.016
117. Tyrka, A. R., Waldron, I., Graber, J. A. and Brooks-Gunn, J. (2002). Prospective predictors of the onset of anorexic and bulimic syndromes. *Int J Eat Disord*, 32(3), 282–290. Doi :10.1002/eat.10094
118. Uher, R., Brammer, M. J., Murphy, T., Campbell, I. C., Ng, V. W., Williams, S. C. and Treasure, J. (2003). Recovery and chronicity in anorexia nervosa: brain activity associated with differential outcomes. *Biol Psychiatry*, 54(9), 934–942. Doi :10.1016/s0006-3223(03)00172-0
119. Voelker, D., Reel, J. and Greenleaf, C. (2015). Weight status and body image perceptions in adolescents: current perspectives. *Adolesc Health Med Ther,* 20156 (6), 149-58. Doi: 10.2147/AHMT.S68344
120. Vögele, C., and Gibson, L. (2010). Mood, emotions and eating disorders. In: Oxford Handbook of Eating Disorders. Series: Oxford Library of Psychology. Oxford University Press-New York: 180-205.
121. Wade, T. D., Bergin, J. L., Tiggemann, M., Bulik, C. M. and Fairburn, C. G. (2006). Prevalence and long-term course of lifetime eating disorders in an adult Australian twin cohort. *Aust N Z J Psychiatry*, 40(2), 121–8. Doi:10.1080/j.1440-1614.2006.01758.x.
122. Wagner, A., Aizenstein, H., Mazurkewicz, L., Fudge, J., Frank, G. K., Putnam, K., Bailer, U. F., Fischer, L. and Kaye, W. (2008). Altered insula response to taste stimuli in individuals recovered from restricting-type anorexia nervosa. *Neuropsychopharmacology*, 33(3), 513–523. Doi :10.1038/sj.npp.1301443
123. Wagner, A., Aizenstein, H., Venkatraman, V., Fudge, J., May, C., Mazurkewicz, L., Frank, B., Bailer, U., Fischer, L., Nguyen, V., Carter, C., Putnam, K. and Kaye, W.

(2007).Altered reward processing in women recovered from anorexia nervosa. *Am J Psych*, 164(12),1842–1849. Doi :10.1176/appi.ajp.2007.07040575

124.Wagner, A., Barbarich-Marsteller, N. C., Frank, G. K., Bailer, U. F., Wonderlich, S. A., Crosby, R. D., Henry, S. E., Vogel, V., Plotnicov, K., McConaha, C. and Kaye, W. H. (2006). Personality traits after recovery from eating disorders: do subtypes differ? *Int J Eat Disord*, 39(4), 276 –284. Doi :10.1002/eat.20251

125.Walf, A. A. and Frye, C. A. (2006). A review of mechanisms of estrogen in the hippocampus and amygdala for anxiety and depression behavior. *Neuropsychopharmacology*, 31(6), 1097–1111. Doi :10.1038/sj.npp.1301067

126.Weisstaub, N., Zhou, M., Lira, A., Lambe, E., González-Maeso, J. and Hornung, J. (2006). Cortical 5-HT2A receptor signalling modulates anxiety-like behaviors in mice. *Science*, 313(5786), 536–540. Doi :10.1126/science.1123432

127.Westen, D. and Harnden-Fischer, J. (2001). Personality profiles in eating disorders: Rethinking the distinction between axis I and axis II. *Am J Psychiatry*, 158(4), 547–562. Doi :10.1176/appi.ajp.158.4.547

128.Winstanley, C. A., Chudasama, Y., Dalley, J. W., Theobald, D. E., Glennon, J. C. and Robbins, T. W. (2003). Intra-prefrontal 8-OH-DPAT and M100907 improve visuospatial attention and decrease impulsivity on the five-choice serial reaction time task in rats. *Psypchopharmacology (Berl.)*, 167(3), 304–314. Doi :10.1007/s00213-003-1398-x

129.Zink, C. F. and Weinberger, D. R. (2010). Cracking the moody brain: the rewards of self starvation. *Nat. Med*, 16 (12), 1382–1383. Doi :10.1038/nm1210-1382